Yellowstone Co.

ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Lroof RH DATE: 7/8/93

1. Pat C. PPC
2. Jon D JD
3. Roger RCT

- [x] Approval
- [ ] Comment
- [ ] Necessary Action
- [ ] Note and Return
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- [ ] Investigate
- [ ] Prepare reply
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- [ ] See Me
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- [ ] For your information
- [ ] Per Conversation

REMARKS:

sw/ laurel. apl

FROM: p 3

mailed 7-9-93 lh

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
(406) 444-1430
MARC RACICOT, GOVERNOR
FAX # (406) 444-1499

STATE OF MONTANA

OFFICE LOCATION 836 Front Street Helena, Montana
MAILING ADDRESS: PO BOX 200901 Helena, MT 59620-0901

July 8, 1993

Jim Worthington, Public Works Director
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: **LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY - LICENSE NO. 203** APPROVAL FOR 2 ADDITIONAL MONITORING WELL LOCATIONS AND SCHEDULE OF EVENTS.

Dear Mr. Worthington:

GeoResearch, Inc. has been very helpful in providing concise and adequate data for the Department to make an informed approval of the 2 proposed additional monitoring well locations (i.e. 93MW-1 and 93MW-2). The Schedule of Investigatory Events is very inclusive and should be executable. Hopefully, this additional data will provide enough information to determine the present extent and nature of the leachate contaminants detected in the ground water analytical results, as well as any additional constituents to come, and/or increased concentrations.

It will be essential to evaluate all of this site hydrogeologic data in a thorough manner. This may include considering various aspects of possible remediation alternates for corrective action which may be necessary in the immediate future in cleaning up the contamination found in the ground water at this site.

If you have any questions, please give me a call.

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist

cc: Margaret Hofacker, GeoResearch, Inc., 115 N. Broadway, Billings, MT 59101
Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Dept., P.O.Box 35033, Billings, MT 59107
Chuck Rogers, Mayor, City of Laurel, P.O.Box 10, Laurel, MT 59044
Kevin Chappell, Surface Management Bureau, MT Dept. of State Lands, 1625 Eleventh Ave., Helena, MT 59620

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Yellowstone

ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Proof fit

DATE: 6/22/93

1. Pat C. PPC
2. Jon D JD
3. Roger/Duane per DLR

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REMARKS:

sw/laurel.res

mailed & faxed 6-24-93 DH

FROM: p 3

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
(406) 444-1430
MARC RACICOT, GOVERNOR
FAX # (406) 444-1499

STATE OF MONTANA

OFFICE LOCATION 836 Front Street Helena, Montana
MAILING ADDRESS: PO BOX 200901 Helena, MT 59620-0901

June 23, 1993

Jim Worthington
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: **LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY - LICENSE NO. 203** REVIEW AND COMMENTS ON MAY, 1993 GROUND WATER SAMPLING EVENT, AND FINALIZATION OF HYDROGEOLOGIC AND SOILS REPORT.

Dear Mr. Worthington:

The analytical results from the May, 1993 ground water sampling event at the Laurel Class II Landfill confirms the previous results found in the November, 1992 analysis. Dichlorodifluoromethane is a re-occurring volatile organic compound (VOC) that has been found in measurable concentrations in the ground water in monitoring well MW-2 at this site in both the November, 1992 and May, 1993 sampling events. The analyses from the May, 1993 sampling event also found measurable concentrations of trichlorofluoromethane in the ground water at MW-2.

VOCs are not naturally occurring in the ground water. Therefore, any VOC concentrations found to be statistically significant over background (e.g. background being equal to zero), would indicate the quality of the waters of the State has undergone some degree of degradation. Degradation of the waters of the State is in violation of 75-5-303, of the Montana Code Annotated (MCA), and the Water Quality Act.

The Department strongly suggests based on the Administrative Rules of Montana (ARM) 16.14.708(1)(d), that the City of Laurel drill a deeper monitoring well in the immediate vicinity (i.e. clustered) of MW-2. This deeper monitoring well would help to determine if there has been any **vertical downward migration** of VOCs into the next lower water-bearing unit beneath the one that is completed in MW-2. Extreme care must be taken to case and seal-off the upper water-bearing unit before drilling ahead to the next lower water-bearing unit. Cross contamination of the ground water associated with the various thin shale beds during drilling and completion of the well must be avoided.

An additional hydraulically down gradient well should be located proximal to the edge of the contaminant plume to determine the **lateral extent** of contamination. The approximate location of this additional well can be estimated by calculating the vertical rate of migration to the first water bearing unit, followed by calculating the horizontal migration rate based on the period of time that the landfill has been in existence.

Evidence from other leaking landfills in the State confirms that the less dense, more volatile chemical constituents (i.e. dichlorodifluoromethane) of a leachate plume migrate at a faster rate in the ground water than the more dense, non-aqueous phase liquids (DNAPLs), such as tetrachloroethene. Therefore, the concentrations of **dichlorodifluoromethane** measured in the ground water at MW-2, may be an indication of DNAPLs yet to arrive at this monitoring location.

Also, according to the analytical results from the May, 1993 sampling event, the concentration of **chlorides** in the ground water in MW-3 are nearly double those measured in MW-1, MW-2, and MW-4. Relatively high concentrations of chloride in the ground water have been known to act as a precursor of chemical contamination soon to follow. Chloride readily dissolves in water and moves at about the same rate as water (i.e. chloride has nearly the same density as water). It is imperative that MW-3 be closely monitored to determine if, and when, VOCs are detected in the ground water at this monitoring point. In the event that MW-3 becomes impacted, at least one additional down gradient well will be required to monitor the lateral extent of the plume in the south-southwestern direction.

It is highly recommended by the Department that when sampling for VOCs in wells that have detectable concentrations of one or more VOCs, the "long list" of chemical constituents for USEPA Method Number 8260 be run. This expanded list of VOCs includes those constituents required in the ARM 16.14.706 Table 1 list, plus 34 additional VOCs. I understand that there is no additional charge for this expanded list of VOC constituents. However, this may only be applicable if you are using Energy Labs for your ground water analysis.

It is also unfortunate that once again the deionized (DI) water used for equipment decontamination has had measurable levels of VOCs in it (i.e. methylene chloride and chloroform). This problem needs to be corrected for future sampling events.

Please note that as part of the ARM 16.14.706(4), ground water level measurements in the monitoring wells are to be measured and recorded monthly for a period of 1 year to determine seasonal

water levels fluctuations. The City of Laurel may commence these monthly water level measurements beginning with the May, 1993 data which has already been collected and reported with the May analytical results.

Concerning the request by GeoResearch (in a faxed memo dated May 16, 1993) for an extension on the submittal date for the hydrogeologic and soils study/report, the Department would be agreeable to grant such an extension. However, this extension would be made under the assumption that any additional monitoring well installations and analytical data from any additional sampling events would be accomplished in a timely enough fashion to be able to include this information in the final report.

Based on the additional hydrogeologic requirements set forth in this letter. The Department requests that Laurel confirm the necessary additional work in a brief schedule, including the precise events and approximate time-frames in which this additional work will be accomplished. This schedule should include the estimated time necessary for the submittal of a draft of the final Hydrogeologic and Soils Report.

Please provide a map of the proposed new monitoring well locations and support these proposed locations with rate of migration calculations using the best hydrogeologic information available from the site investigatory work, to date. Note that monitoring wells cannot be located greater than 450 feet from the waste management unit boundary, unless conditions indicate contamination may exist at distances greater than this. It appears that any additional down gradient wells needed at the City of Laurel Landfill will have to be installed on privately owned property. Permission will need to be acquired from the owner(s) prior to drilling on their property, and an access agreement for sampling and well maintenance will be necessary.

This letter covers a lot of loose-ends, so if you have any questions please give me a call.

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist

cc: Margaret Hofacker, GeoResearch,Inc., 115 N. Broadway, Billings, MT 59101
Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107
Chuck Rogers, Mayor, City of Laurel, P.O. Box 10, Laurel, MT 59044
Kevin Chappell, Surface Management Bureau, Montana Department of State Lands, 1625 Eleventh Ave., Helena, MT 59620

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Jim Worthington
City of Laurel
P.O. Box 10
Laurel, MT 59044

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Solid & Hazardous Waste Bureau
836 Front Street
Helena, MT 59620

Attn P3

Yellowstone

ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Roof 4th DATE: 3/24/93

1. PAT C. ✓ / Jim W ✓
2. Roger
3. Jon D. JD

☑ Approval	☐ Comment	☐ Necessary Action
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REMARKS:

SW/laurel. HSS

FROM: P3

mailed 3-30-93 lm

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
(406) 444-1430
MARC RACICOT, GOVERNOR
FAX # (406) 444-1499

STATE OF MONTANA

OFFICE LOCATION 836 Front Street Helena, Montana
MAILING ADDRESS: PO BOX 200901 Helena, MT 59620-0901

March 29, 1993

CERTIFIED LETTER

Mr. Jim Worthington
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: **LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY - LICENSE NO. 203**
REVIEW OF THE HYDROGEOLOGICAL AND SOILS REPORT.

Dear Mr. Worthington:

The most immediate point of concern raised from the results of the Hydrogeological and Soils Study conducted at the Laurel Class II Landfill facility deals with the analytical results from sampling the ground water at the four (4) newly installed monitoring wells. The exceedence over background of the chemical constituent dichlorodifluoromethane (i.e. 4.3 ug/L) in the ground water collected at monitoring well MW-2 will require the owner/operator, according to the Administrative Rules of Montana (ARM) 16.14.708(1) to:

Initially — Re-sample all of the wells. All wells will need to be sampled for the spring event anyway. MW-2 should be the well selected for duplicate analysis. This sampling event should be conducted promptly to attempt to sample during high ground water associated with spring.

The chemical characteristics of dichlorodifluoromethane indicate that it is one of the more mobile volatile organic compounds (VOCs). The presence of dichlorodifluoromethane in the ground water could be indicative of the advancing edge of a horizontally migrating plume of possible leachate contamination, and/or a vertically migrating plume of dense non-aqueous phase liquids (DNAPL). Dichlorodifluoromethane (fluorocarbon-12) is a

colorless, non-corrosive gas. It is nearly insoluble in water. Common uses of dichlorodifluoromethane are as an aerosol propellant and refrigerant.

Chloroform is a colorless and heavily reactive liquid with a characteristic odor. It is used in analytical chemistry as a solvent, as an expansion agent in styrofoam, and as a fumigant. With the exceedence of chloroform being analyzed in the equipment blank, and no detectable concentrations of chloroform found in the monitoring well samples, all indications substantiate this to be a constituent unrelated to the ground water analysis at this site. The Department acknowledges the nature of methylene chloride to be a laboratory contaminant.

Concentrations of various inorganic parameters such as chlorides, nitrates, and the chemical oxygen demand (COD) are also elevated above background concentrations, and in some instances exceed maximum contaminant levels (MCLs) and/or secondary drinking water standards. Dissolved metals concentrations are also above background in several instances. The re-sampling event will provide an opportunity to re-evaluate these results.

Secondly — The installation of additional cross-gradient and downgradient wells may be required to determine the lateral and vertical extent of any possible plumes of contamination that might be emanating from the landfill. The results from the re-sampling event should provide further conclusive data, as to the need for additional monitoring wells.

Beyond the State rule requiring the landfill to re-sample the groundwater, the following deficiencies were noted in the overall review of the Hydrogeological and Soils Report:

1) Concern arises as to the extremely thin water-bearing zone screened (i.e. 5 feet of screened interval) in the 4 newly installed ground water monitoring wells. Based on the fractured nature of the water-bearing shales in which these wells were screened, it is essential that the following requirements be specifically addressed:

16.14.703(1)(a)(iii) — "Based on field data, tests, and cores, preparation of representative and accurate classification and description of the hydrogeologic units which may be a part of the leachate migration pathways at the facility (including saturated and unsaturated units):"

16.14.703(1)(a)(iii)(C)	"an interpretation of the relative degree of interconnections between saturated zones;"
16.14.703(1)(a)(iv)(C)	"zones of fracturing or channeling in both horizontal and vertical directions in consolidated and unconsolidated deposits;" (determine if additional water-bearing zones are present beneath the 5-feet of screened interval).
16.14.703(1)(a)(v)(C)	"the flow system including the vertical and horizontal components of flow;" (in this case discuss the confined/unconfined nature of this water-bearing zone).

The Administrative Rules of Montana (ARM) also require that the depth to the aquifer be determined, as well as the thickness of the aquifer and the lithology of the confining layer beneath the aquifer [see ARM 16.14.703(1)(a)(iv)(A) through (F)]. By identifying the above aquifer criteria, the vertical extent of any dense non-aqueous phase liquids (DNAPLs) can be determined.

Installation of additional deeper monitoring wells (possibly in cluster patterns) may be required following the analytical results of this spring's sampling event immediately at hand. If any of the wells are discovered to be dry during the required monthly water level measurements (see item #8, below), new/deeper wells may also be necessary.

2) Unsaturated zone hydraulic conductivity data measured using the Guelph permeameter is inconclusive at this site, as stated in the report. Hydraulic conductivities in the unsaturated zone shall be determined according to ARM 16.14.703(1)(a)(x).

3) The results of the infiltration test attempted at R-1 are considered to be invalid or unreliable due to freezing conditions at the site. This type of test, or another approved, shallow unsaturated zone test method will need to be conducted in an effort to obtain more valid results.

4) A ground water gradient has been provided in the text as 0.012 ft/ft. The reliability of this calculation is questionable due

to the unconfined and confined nature of the water-bearing zone being monitored. If the monitoring wells are not screened in the same water-bearing zone (as mentioned in the text), additional wells will be required to provide contiguous information on the quality of the water from upgradient to downgradient at the site.

5) Measuring the dissolved oxygen content to determine the movement and/or interconnection of the ground water in this shallow water-bearing unit(s) was suggested in this report, but apparently was not done. This could be a helpful test that might be run in the field during the next ground water monitoring sampling event.

6) With storativity values being high in the "confined" monitoring wells, questions arise as to whether the appropriate method for the calculation of transmissivities were used. Please re-evaluate this data in lieu of the any additional information obtained during finalization of the required hydrogeological field work (see items #1, 4).

7) Please provide lithologic descriptions for the following excavations: G-1, G-2, G-3 and R-1, as well as a description of the soils at excavations L-1 and L-2.

8) Monthly ground water level measurements are required for the first year of ground water monitoring to determine the high and low water level seasons at this location [see ARM 16.14.706(4)].

9) Monitoring wells need to be locked at all times to protect the integrity of the wells and the quality of the ground water [see ARM 16.14.705(7)].

This report has numerous areas of "inconclusive" and "unreliable" data, as described in the text of this report. In some instances, conclusions were reached using this information that may be totally inaccurate. Much of this questionable data has to do with field tests that were conducted during bad weather conditions. These tests should have been re-run before this report was submitted to the Department.

The Montana Department of Health and Environmental Sciences Solid Waste Program (the Department) views this report, dated December 31, 1992 as a status update to the final version of the required Hydrogeological and Soils Report. We strongly encourage sampling of the existing ground water monitoring wells as soon as possible, and request that the required data be submitted to the Department in the form of a <u>final</u> report within 90-calendar days from the date of this letter.

If you have any questions concerning more specific aspects to the deficiencies listed above, please give me a call.

Please note that according to ARM 16.14.708(4), if there is an exceedence (i.e. increase over background) of a ground water monitoring parameter or chemical constituent, the facility is required to notify the Department in writing within 15 days of the discovery of the exceedence.

Sincerely,

Pat Potts
Environmental Specialist

cc: Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107

Chuck Rogers, Mayor, City of Laurel, P.O. Box 10, Laurel, MT 59044

Kevin Chappell, Surface Management Bureau, Montana Department of State Lands, 1625 Eleventh Ave., Helena, MT 59620

Margaret Hofacker, GeoResearch, Inc., 115 North Broadway, Billings, MT 59101

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file: yellowstoneco\laurel\grd wtr

ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Proof Ltr DATE: 10/26/92

1. ~~Pat C~~ / Jim W JW
2. ~~Jon D~~ Jon D. JD
3. ~~Roger / Duane~~

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REMARKS:

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FROM: P 3

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
(406) 444-1430
STAN STEPHENS, GOVERNOR
FAX #(406) 444-1499
STATE OF MONTANA
OFFICE LOCATION: 836 Front Street Helena, Montana
MAILING ADDRESS: Cogswell Building Helena, MT 59620

October 26, 1992

Chuck Rogers, Mayor
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: APPROVAL OF THE WORKPLAN FOR LAUREL LANDFILL, YELLOWSTONE COUNTY, LICENSE NO.203

Dear Mr. Rogers:

Based on the information provided in the original Workplan dated September 4, 1992, the comments submitted on October 14, 1992, and the final response to the duplicate sampling requirement dated October 26, 1992, the Montana Department of Health and Environmental Sciences Solid Waste Program (the Department) **approves** the above data as the complete Workplan for the Hydrogeological and Soils Study at the City of Laurel's Class II landfill. Implementation of this Plan may begin immediately.

The City of Laurel has 180 calendar days from the date of this approval to submit the Hydrogeological and Soils Study information in a final report to the Department [see the Administrative Rules of Montana (ARM) 16.14.703(1)(c)(ii)(C).

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist file:sw\laurel.app

cc: Curt Coover, P.G., Project Hydrogeologist, GeoResearch, Inc., P.O. Box 5597, Helena, MT 59604
Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107
Cal Cumin, Director of Public Works, Planning Department, 907 Avenue B, Billings, MT 59102

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Yellowstone

ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Proof CJ DATE: 10/21/92

1. _____
2. Jon D JD
3. Roger RC 4. Duane DR

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REMARKS:

SW\ laurel.wkz

Laura - please file the document from Geok. after routing. Thanks

FROM: P 3

mailed 10-23-92 EN

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
(406) 444-1430
STAN STEPHENS, GOVERNOR
FAX #(406) 444-1499
STATE OF MONTANA
OFFICE LOCATION: 836 Front Street, Helena, Montana
MAILING ADDRESS: Cogswell Building, Helena, MT 59620

October 21, 1992

Chuck Rogers, Mayor
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: REQUIREMENTS FOR APPROVAL OF THE WORKPLAN FOR THE LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY, LICENSE NO. 203

Dear Mr. Rogers:

Overall the responses from GeoResearch dated October 14, 1992 to the comments made in the review of the original Workplan by the Montana Department of Health and Environmental Sciences, Solid Waste Program (the Department) on the above-referenced facility are adequate. These comments will be attached to the original Workplan.

There are some issues that must be reiterated in greater detail. These issues are:

1) Normal drilling and sampling procedures do recommend drilling upgradient, or beginning at the location of least possible contamination first. However, concern expressed in the Workplan as to possibility of not encountering any groundwater in the first two borings proposed at the site, lead the Department to recommend at least one of the downgradient wells be drilled first.

This was based on a greater natural tendency to encounter groundwater in a downgradient ephemeral drainage, than topographically, up the hill at the transfer station location. If decontamination procedures are effective, the order of drilling should not matter. It depends if finding groundwater is of initial concern at this site.

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2) Although the RCRA "Technical Enforcement Guidance Document" (TEGD, pg.54) states that screens should span no more than a single flow zone, because an excessive length of screen in a well may permit uncontaminated formation water to dilute the contaminated groundwater entering the well, the extreme variability of seasonal (and other influences) water level fluctuations experienced within the State must be taken into consideration. Therefore, additional lengths of screening may be necessary in groundwater monitoring wells to ensure the year-round presence of water in the wells. This will require a site-specific judgement based on information acquired as the wells are drilled.

Please clarify the following issues concerning duplicate sampling at this site:

GeoResearch's Standard Operating Procedures (SOP) included in Appendix B of the original Workplan states that:

> "One duplicate sample should be collected for every ten samples or one per day, whichever is greater."

Sampling at the Laurel Landfill site should be considered **one day of sampling**, therefore a field duplicate is required.

If you intend to collect groundwater samples from the monitoring wells after installation and development, prior to submitting a Sampling Analysis Plan for approval by the Department, explain why you will not be collecting a duplicate sample for analysis per each sampling event as stated in GeoResearch's SOP.

With reference to the Administrative Rules of Montana (ARM) concerning duplicate samples and sample blanks required under an approved SAP, ARM 16.14.706(1)(b)(i)(C)(I) **and** (II) states that a QA/QC plan will include field QA/QC methods, such as the frequency of QA/QC samples for duplicates, **and** blanks. This is not an either/or choice, both QA/QC samples are required, and "zero" frequency for these QA/QC samples is **not** an option.

A Department-approved SAP is required for purposes of validation of the analytical results. Due to the ambiguities already associated with the interpretation of the application of the company SOP presented by GeoResearch, it is entirely possible that the integrity of the samples and the analytical results may be questionable. Please clarify your intent in the submittal of GeoResearch's SOP.

The Department earnestly hopes that the City of Laurel will take these comments into consideration. A response concerning the issue of the duplicate samples and GeoResearch's SOP are necessary so that the Workplan may be approved and the hydrogeological and soils investigation may commence.

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist

cc: Curt Coover,P.G., Project Hydrogeologist, GeoResearch, Inc., P.O. Box 5597, Helena, MT 59604

Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107

Cal Cumin, Director of Public Works, Planning Department, 907 Avenue B, Billings, MT 59102

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ROUTE SLIP

DEPARTMENT OF HEALTH & ENVIRONMENTAL SCIENCES

TO: Roop CW DATE: 9/29/92

1. Jim W. JW / Pat C. PPC

2. Jon D JD

3. Roger / Duane DHC Rec

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FROM: P 3

DEPARTMENT OF
HEALTH AND ENVIRONMENTAL SCIENCES
Solid and Hazardous Waste Bureau
Solid Waste Program
STAN STEPHENS, GOVERNOR (406) 444-1430
FAX #(406) 444-1499
STATE OF MONTANA
OFFICE LOCATION: 836 Front Street Helena, Montana
MAILING ADDRESS: Cogswell Building Helena, MT 59620

October 6, 1992

Mr. Chuck Rogers, Mayor
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RE: **LAUREL CLASS II LANDFILL, YELLOWSTONE COUNTY**
LICENSE NO. 203
REVIEW OF THE WORKPLAN FOR THE HYDROGEOLOGICAL AND SOILS STUDY.

Dear Mr. Rogers:

On September 9, 1992, the Montana Department of Health and Environmental Sciences Solid Waste Program (the Department) received the Workplan for the above-referenced facility from Mr. Curt Coover, Project Hydrogeologist with GeoResearch, Inc. on behalf of the City of Laurel.

The following comments, corrections and deficiencies are presented in the order in which they appear in the Workplan and are numbered accordingly by applicable section. These items will need to be addressed before the Workplan can be approved by the Department:

1.0 INTRODUCTION

Specifically, 40 CFR Part 258, Subpart E (i.e. "Subtitle D" groundwater monitoring requirements become effective on October 9, 1993. Therefore, the site would have to be closed by October 9, 1993 (not 1994, as stated in the Workplan text) for the federal requirements for groundwater monitoring to be non-applicable.

2.0 SITE DESCRIPTION

A. The old site (license no. 24) is not required to have a groundwater monitoring plan because it does not meet the criteria according to Section 75-10-207(1), Montana Code Annotated (MCA), [not Section 75-10-204(5), MCA, which outlines the powers and duties of the Department].

B. In reference to the landfill areas shown on Figure 2-2 of this Workplan, where was the "old dump site" located which was opened in 1965?

C. Provide a contour map showing the topography and drainage of this site since cover has been applied [see ARM 16.14.703(1)(a)(ii) & ARM 16.14.703(1)(a)(vi)].

D. Explain why you think neither the shallow gravels mapped to the north of the site, nor the Yellowstone Valley gravel unit described as being south of the site will not be present at this site. Does this site represent a divide or permeability barrier between the north and south gravel deposits? What happens to the water in the shallow gravels to the north, if drainage is to the southeast?

E. The proposed maximum depth of drilling (150 feet) at the site must take into account the extent of the hydrogeologic units at the site. This would include establishing the thickness of the uppermost aquifer and determining the underlying confining layer in at least one boring [see ARM 16.14.703(1)(a)(iv)].

F. **FIGURE 2-2.**
Please add "R-1" to the legend.

3.0 PROPOSED INVESTIGATION

3.1 Soil Investigation.

A. Additional reasons for <u>not</u> drilling through the refuse on-site are the possibility of introducing contamination down into the aquifer with the drilling equipment, and materials sloughing into the lower portion of the hole from the waste zone above.

B. Will soil samples collected for laboratory tests (i.e. grain size distribution, total organic carbon (TOC), soil pH, moisture content and density) be collected from both the unsaturated and saturated zones, except for moisture content which will be measured from unsaturated zone soil materials?

3.2 Groundwater Investigation.

A. Required groundwater sampling parameters are located in **<u>Table 1</u>** of ARM 16.14.706.

B. It is also important to be cognizant of ARM 16.14.712(2) which states that if closure is not achieved by January 1, 1993, semi-annual sampling events will be required through the 30 year post-closure period.

C. Do you plan to drill the borings/monitoring wells in the labeled numeric order presented on the map in Figure 2-2? Please refer to the Department's comments under Section **3.2.1.**

D. If groundwater is <u>not</u> encountered in the "first two test borings" (please refer to the enclosed topographic map for the exact re-locations of the wells recommended by the Department for DMW4 and DMW3, which should be drilled first and second, respectively), after being drilled to 150 feet with the intent to leave these holes "open" (i.e. uncased, except for shallow surface pipe) to monitor for groundwater seepage into the holes, consider the following:

1. If these boreholes are intended to be used for groundwater monitoring, they must initially be sealed at the surface, capped and locked following drilling. This is to prevent surface contamination due to run-on/run-off and/or any additional outside forces that might alter the natural quality of the water and possibly impact the aquifer. Sealed capped and locked monitoring wells also deter tampering and vandalism [see, ARM 16.14.705(7)].

2. Allowing borings to remain open/uncased for extended periods of time for the purposes of water collection from seepage zones in the open borehole, could allow contaminated water from shallow low permeability and/or low volume zones of moisture to run down the walls of the hole and mix/cross-contaminate deeper, unimpacted zones water-bearing zones [see, ARM 16.14.705(6)]. This will not be considered an acceptable procedure if borings are allowed to remain open (i.e. uncased) more than one day.

3. Slopewash, gravels and/or colluvium from the upper portion of the hole will probably slough sufficiently into the hole to naturally prevent leaving these boreholes open for any extended period of time (i.e over-night).

E. In the event that the first two test borings are dry, the suggestion presented in the Workplan requesting a no-migration petition may be considered by the Department. However, it is most likely that all four (4) proposed borings/monitoring wells will be required to adequately evaluate the soil characteristics and hydrologic conditions over the entire 10-acre site. Total depths of the borings

may be limited to at least 20 feet below the depth of buried waste, as well as reconsidering the value of any additional monitoring well installations.

Also, note that the depth of borings/monitor wells drilled at a site does not independently constitute sufficient conditions to request a no-migration petition. Soil characteristics such as homogeneity, and vertical and horizontal hydraulic conductivities are also essential elements in considering the site applicability for a no-migration petition.

NOTE: Previous groundwater history at the site indicates that shallow groundwater has been encountered during trenching operations, primarily associated with the west side of the site. Inspection reports conducted by the Department in July 1, 1988 and May 3, 1989 document the presence of groundwater at 10 feet below the ground surface in two test borings, as well as in the landfill trench at a depth of 10 feet below the ground surface at the time of the May, 1989 inspection. A depth to groundwater "checking procedure" was initiated at this site to avoid excavating additional trenches deeper than 10 feet above the groundwater table.

Based on the above information concerning the presence of shallow, possibly perched or seasonal groundwater bearing zones having been in close proximity and in contact with the refuse in some cases at this site, it is critical that these shallow water-bearing zone(s) be isolated and monitored separately from the uppermost aquifer system.

The Department would like to recommend clustering DMW4 (DMW4A) and DMW3 (DMW3A). With the "A" series wells being installed separately in the uppermost water-bearing zone(s). These upper zones may consist of water-bearing shale bedding planes acting as conduits for the transmission of shallow water sources. Initially, two shallow (i.e. 10 to 35 feet deep) monitoring wells should be constructed at the indicated locations shown on the accompanying topographic site map, DMW4A and DMW3A.

If sufficient quantities of groundwater are encountered in these shallow wells, the need for deeper monitoring will only be required if this uppermost zone reflects impacts in the natural quality of the water due to landfilling operations related to the Laurel Landfill site. A background well in this shallow zone/aquifer will also be required to make this water quality determination.

3.2.1 Number and Location of Monitoring Wells.
A. The proposed upgradient monitoring well location is off-site. Explain the ownership of the property where this well will be located, the terms under which you will be granted access, and monitoring well installation rights.

B. Please refer to the enclosed map of the originally undisturbed site topography. Note the proposed monitoring well re-locations based on the original topographic features on the property prior to landfilling operations. The Department believes that DMW4 should be installed first to locate the depth to possible shallow water-bearing units associated with the drainage/coulee to the south-southeast. If no shallow zones are encountered in this first attempt, the well should be drilled to the uppermost aquifer.

DMW3 should be drilled second to provide a means of monitoring groundwater possibly associated with the trenching operations on the west side of the site and in conjunction with the topographically low area on the west side of the high (i.e. elevation 3558.62 feet). Note the revised location for DMW2 on this map as well. MW1, the proposed background well location may remain as originally spotted assuming lithologic and hydrogeologic units can be correlated to the downgradient wells.

3.2.2 Monitoring Well Installation and Construction.
A. Decontamination of the drilling equipment is essential and should also be done <u>prior to</u> working on the site, as well as between borings [see, ARM 16.14.705(3) & (4)].

B. What screen lengths do you intend to use in each well? If you decide screen lengths greater than 10 feet will be used in monitoring well construction, please consider the dilution factor associated with extensive lengths of screen, and explain your reasoning for the proposed additional length of screened interval(s).

3.2.3 Hydraulic Conductivity.
A. Using the Guelph permeameter to determine hydraulic conductivity in the unsaturated zone (i.e. 2 to 4 feet deep), explain how "<u>total</u> (horizontal plus vertical) unsaturated hydraulic conductivity" is applicable. Can the horizontal and vertical values be determined separately? Explain how these numbers are used with relevance to the actual individual horizontal and vertical hydraulic conductivities.

Will these Guelph permeameter tests be single head or the standard-two head method? What is matrix flux potential and how is it measured? How do you arrive at the soil parameter value? From what data do you get the reservoir area, is this just around the borehole or does it represent the entire aquifer reservoir?

Possibly by supplying the Department with Soilmoisture Equipment Corp.'s operations manual and applicable data interpretations and/or calculations, the above questions can be addressed in the necessary detail. A diagram would be nice with descriptions of the equipment involved, such as the porous/ceramic(?) base to the permeameter and what part the "ring(s)" play in the installation of the equipment. Propriety information will be handled as such upon request. It will not become part of the general solid waste files which are open to the public.

B. The Workplan states that a "field saturated" vertical hydraulic conductivity test (i.e. R-1) will be "conducted" at a depth of "approximately" 10 feet. Define "field saturated". Explain how this test will be "conducted". Provide the procedure and methodology involved in attaining an accurate "field saturated" vertical hydraulic conductivity.

How deep must the single ring be driven into the bottom of the hole to eliminate the compacted/sand-blasting "skin" effect from the sides and bottom of the borehole caused by drilling?

3.2.4 Table 3-1
Why aren't groundwater samples collected for volatile organic compound (VOC) analysis preserved with hydrochloric acid? See, Table 4-1 from the U.S. EPA SW-846 Test Methods which is enclosed. This Table shows (in footnote #1) liquid volatile organics samples must be preserved with one of the three (3) types of preservatives listed (i.e. H_2SO_4, HCl or solid $NaHSO_4$).

3.2.5 Sample Procedures.
A. Please note in the text of this Workplan that GeoResearch's Standard Operating Procedures (SOP) provided in Appendix B of this Workplan is merely a preliminary sampling and analysis plan (SAP), designed to provide appropriate sampling methodology for initial groundwater sampling at the site. A site-specific SAP must be provided to the Department coincident with the Groundwater Monitoring Plan for Departmental approval.

B. See comments under "Appendix B" concerning GeoResearch's SOP.

3.2.6 QA/QC
A duplicate sample and complete duplicate laboratory analysis of one well (the particular monitoring well duplicated being varied with each sampling event) per sampling event is required according to ARM 16.14.706(1)(b)(i)(C)(II), not just when there is an "anomalous lab result. . ." as stated in the Workplan text.

Be aware that if an "anomalous lab result", contamination, etc. is detected in a sampling event, the Department may require one or more of the following, according to ARM 16.14.708(1):

(a) re-sample one or more of the monitoring wells;
(b) increase the frequency of groundwater sampling;
(c) conduct monitoring for additional parameters;
(d) install additional monitoring wells to define the nature and extent of contamination; or
(e) prepare a groundwater corrective action plan including an assessment of the impacts and a schedule of implementation for corrective action.

4.0 REPORT AND RECOMMENDATIONS

A. Please be sure to include the following in the Hydrogeological and Soils Study Report: cross section(s) of the site soil correlations and hydrogeologic relationships, a potentiometric surface map, descriptions and delineation of the lateral and vertical extent of the gravels (if encountered), and discuss and locate any man-made influences related to the site soils and hydrogeologic effects.

APPENDIX B -

Checklist 1.
Decontamination Materials should include methanol, hexane, or acetone for rinsing sampling equipment for organics. Nitric acid which is mentioned, or hydrochloric acid is used for rinsing equipment when sampling for inorganics.

2.7 Sample Containers and Preservation.
Marking water levels on sample containers may be one way to determine if leakage or tampering has occurred. Consider placing a seal or tape over the cap of the containers. This

is an effective and recommended method to prevent tampering, especially when sample containers are filled to the top.

2.8 Measurement of Field Parameters.
When using field measurement devices/equipment, it is important to document in the field notebook the manufacturer's name, model, model number and equipment-specific identification number(s). This is done in the event that a particular piece of equipment develops some specific abnormalities discovered either prior to, or after use at the documented site.

To be able to address these questionable issues prior to implementing the Workplan at the Laurel Landfill site, may eliminate any confusion or misunderstanding concerning the necessary data to be acquired for the Hydrogeological and Soils Study Report and the Groundwater Monitoring Plan.

When submitting report(s) pertaining to the Hydrogeological and Soils Study, please provide four (4) copies of the documents to the Department [see, ARM 16.14.703(1)].

The Department hopes to work closely with you and GeoResearch to accomplish the necessary requirements and be able to draw accurate conclusions concerning the nature of the soils and the hydrogeology from the information acquired at this site. If you have any questions, please give me a call.

Sincerely,

Pat Potts

Pat Potts
Environmental Specialist

enclosures

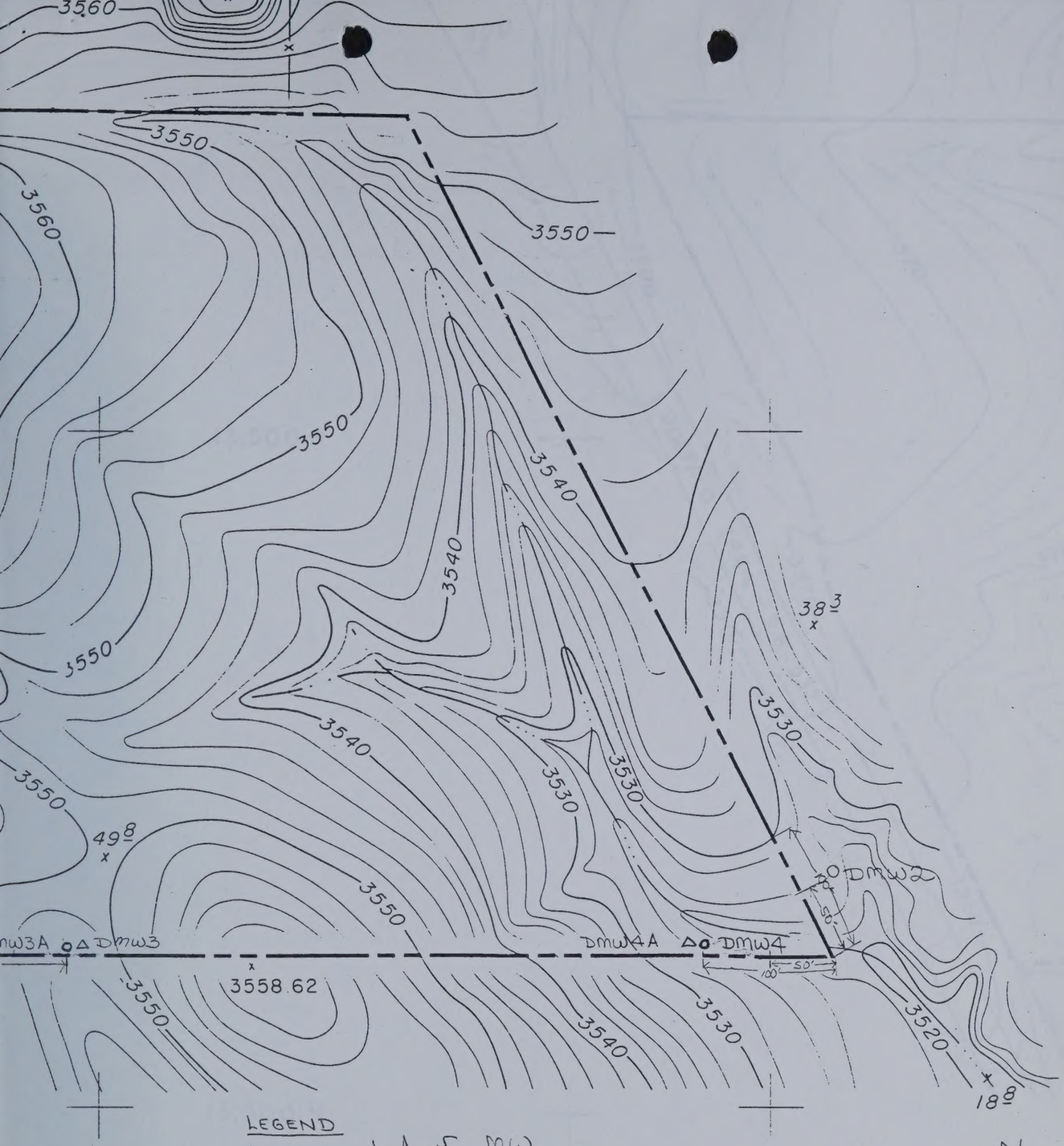
cc: Kevin Chappell, Surface Management Bureau, Montana Department of State Lands, 1625 Eleventh Ave., Helena, MT 59620

Cal Cumin, Director of Public Works, Planning Department, 907 Avenue B, Billings, MT 59102

Dr. George Sheckleton, Yellowstone County Health Officer, City-County Health Department, P.O. Box 35033, Billings, MT 59107

Curt Coover, P.G., Project Hydrogeologist, GeoResearch, Inc., 910 Helena Avenue, Helena, MT 59601

file: sw\laurel.let



LEGEND

○ uppermost Aquifer MW

△ Shallow water-bearing zone(s) MW.

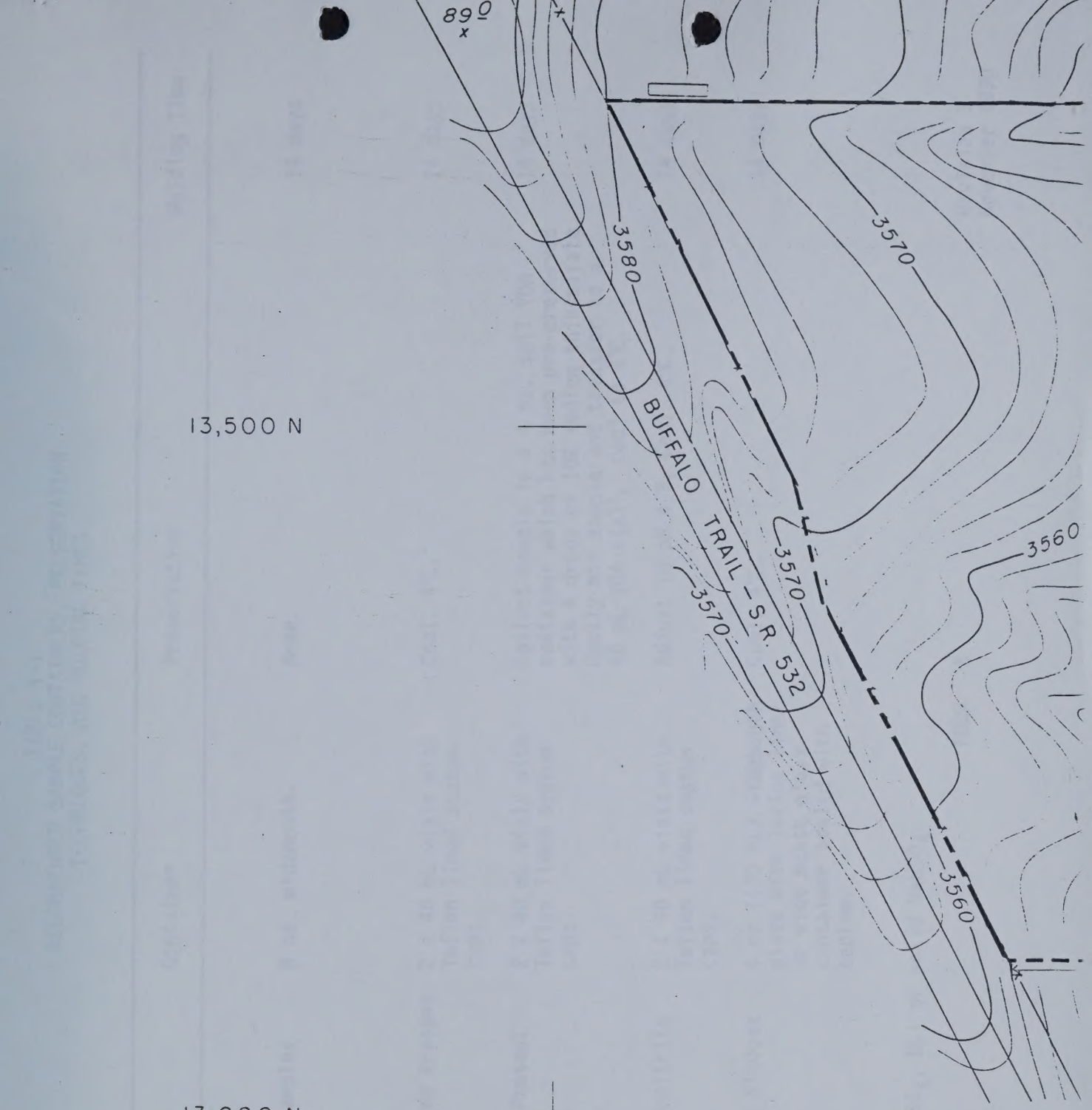
MW Re-locations = DMW locations

LAUREL CLASS II LANDFILL

(scale: 1" = 100')

aerial photo 11/15/79

control surveys conducted 5/12/82


13,500 N
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3580
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3560
BUFFALO TRAIL - S.R. 532

TABLE 4-1.
RECOMMENDED SAMPLE CONTAINERS, PRESERVATION
TECHNIQUES, AND HOLDING TIMES

Analyte Class	Container	Preservative	Holding Time
Volatile Organics			
Concentrated Waste Samples glass with Teflon liner	8 oz. widemouth.	None.	14 days
Liquid Samples			
No Residual Chlorine Present	2 X 40 mL vials with Teflon lined septum caps.	Cool, 4°C.[1]	14 days
Residual Chlorine Present	2 X 40 mL vials with Teflon lined septum caps.	Collect sample in a 4 oz. soil VOA container which has been pre-preserved with 4 drops of 10% sodium thiosulfate. Gently mix sample and transfer to a 40 mL VOA vial[1]. Cool to 4°C.	14 days
Acrolein and Acrylonitrile	2 X 40 mL vials with Teflon lined septum caps.	Adjust to pH 4-5, Cool, 4°C.	14 days
Soil/Sediments and Sludges	4 oz (120 mL) widemouth glass with Teflon liner, or wide mouth glass container sealed with a septum.	Cool, 4°C.	14 days

[1] Adjust pH <2 with H_2SO_4, HCl or solid $NaHSO_4$.

CLOSED
LAUREL LANDFILL
LICENSE NUMBER 203

GEORESEARCH

FALL 1993 GROUND WATER MONITORING

NOVEMBER 1993

IS LOCATED IN THE GROUNDWATER
MONITORING REPORTS ARCHIVE,
BOX NUMBER 8

RECEIVED 11/15/1993

File: Yellwstn Co., Laurel II, grd wtr

GEORESEARCH, INC.

GEO RESEARCH®

August 24, 1993

RECEIVED
AUG 2 5 1993
MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
...EAU

Ms. Pat Potts
Montana Solid Waste Program
P. O. Box 200901
Helena, MT 59620-0901

Re: Laurel Class II Landfill, Yellowstone County - License No.203

Dear Ms. Potts:

This letter is to confirm our telephone conversation this morning. GeoResearch reported a revision of our calculation of the hydrogeological migration rates at the above referenced landfill. The revised calculations are attached. The results of the revison indicate that the horizontal migration rate is approximately five feet per year instead of 46 feet per year. Movement at that rate places the leading edge of the contaminant plume at approximately 35 feet downgradient of MW-2.

Based on this information, you issued a summary recommendation. You stated that installation of the downgradient well, proposed well 93MW-1, may be postponed indefinitely unless either of two situations occurs:

- if concentrations of contaminants in MW-2 quadruple current concentrations, or

- if a signifcant increase in contaminant concentrations is observed in MW-2 between two consecutive sampling events.

You further stated that completion of the Final Hydrogeological and Soils Report will require the installation of a deeper well in the vicinity of MW-2. You also stated that the final report must be completed by October 9, 1993.

Sincerely,

Margaret M. Hofacker

Margaret M. Hofacker
Environmental Engineer

enc: Revised Calculations to Determine Extent of Contaminant Plume, Laurel Landfill
cc: Ms. Peggy Schram, City of Laurel

115 North Broadway
Billings, MT 59101
TEL. (406) 248-6771
FAX (406) 248-6770

Revised Calculations to Determine Extent of Contaminant Plume
Laurel Landfill

Vertical Movement:

Assumption 1: Waste disposal pits were excavated to 10 feet below the original ground surface when active landfilling was occurring.

Assumption 2: The minimum depth to the water bearing zone is 17 feet below the original ground surface in the vicinity of the waste disposal pits.

Assumption 3: Vertical hydraulic conductivity at the site is approximately 8×10^{-8} cm/sec (3×10^{-9} ft/sec).

Calculations:

$$\text{vertical velocity} = 3\times10^{-9}\ \text{ft/sec} \times \frac{3600\ \text{sec}}{1\ \text{hour}} \times \frac{8766\ \text{hours}}{1\ \text{year}} = 0.095\ \text{ft/yr}$$

and

$$\text{time to reach ground water} = \frac{17\ \text{ft} - 10\ \text{ft}}{0.095\ \text{ft/yr}} = 74\ \text{years}$$

Horizontal Movement:

Assumption 1: Horizontal hydraulic conductivity = 3.3×10^{-5} ft/sec.

Assumption 2: Porosity of shale = 10%.

Assumption 3: MW-4 and MW-2 are completed in the same unconfined aquifer.

Assumption 4: The average hydraulic gradient between MW-4 and MW-2 for water level readings taken in November 1992 and May 1993 is 0.047 ft/ft.

Calculation:

$$\text{horizontal velocity} = \frac{3.3\times10^{-5}\ \text{ft/sec} \times 0.047\ \text{ft/ft}}{10} \times \frac{3600\ \text{sec}}{1\ \text{hour}} \times \frac{8766\ \text{hours}}{1\ \text{year}} = 4.89\ \text{ft/yr}$$

revised flow rates

Fact 1: Contamination has been detected in the ground water at MW-2.

Fact 2: On-site information indicates that ground water seepage was detected during trenching activities.

Fact 3: Contamination may have contacted the ground water at approximately the same time that waste was placed in the landfill if it contacted seepage immediately.

Fact 4: Contamination may have been placed upgradient of MW-4 as early as 1965 or as late as approximately 1986 (half way through the life of landfill license #203)

Fact 5: Relative to MW-2, contamination may have been placed as far away as 1150 feet in 1965 or as near as a few feet in approximately 1986.

Assuming purely vertical migration from the waste disposal pits, it is calculated that 74 years will elapse between the time the contamination is placed in the landfill and when it reaches ground water. However, contamination has been discovered in the ground water at the site.

The worst case scenario is that the contamination source was in contact with ground water upon placement in the landfill.

Scenarios:

Scenario 1: Contamination entered the landfill in the first waste load accepted in 1965. Contamination has been moving downgradient for 28 years at a rate of 4.89 feet per year and is calculated to have migrated 137 feet from the northwest corner of the initial dump site and has not reached MW-2 in 1993.

Scenario 2: Approximately half way through the active life of the license #203 area (or 1986) contamination entered the landfill when waste filling was occurring in the vicinity of MW-2. The contamination has been moving downgradient for 7 years at a rate of 4.89 feet per year and is expected to have moved 34 feet downgradient of MW-2.

Recommendation: Because of the estimated proximity of the leading edge of the plume to MW-2, a downgradient well is not recommended at this time. However, clarification of hydrogeological conditions and the presence of heavy contaminants in the next deeper aquifer in the near vicinity of MW-2 should be accomplished with the installation of a deeper well.

File: Yellowstne Co., Laurel (closed), grd wtr.

GEORESEARCH, INC

July 1, 1993

RECEIVED
JUL 0 2 1993
MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

Ms. Pat Potts
Montana Solid Waste Program
P. O. Box 200901
Helena, MT 59620-0901

Re: Laurel Class II Landfill, Yellowstone County - License No.203 Response to Review Comments Dated June 23, 1993.

Dear Ms. Potts:

Enclosed please find a schedule of the planned field investigations at the above referenced landfill. Delivery of the draft final Hydrogeological and Soils Study is scheduled to permit inclusion of data from the installation and sampling of two additional ground water monitoring wells and a September sampling event in the four wells which were installed in 1992.

Calculations of the rate of vertical and horizontal migration are also enclosed. These calculations suggest that the lateral extent of the plume lies 140 to 320 feet down gradient of MW-2. GeoResearch recommends locating the downgradient well 250 feet beyond MW-2.

An application for a land use license from the Department of State Lands, the owner of the property downgradient of the Landfill, is in preparation.

If you have any questions regarding the schedule, the calculations, or the proposed well locations, please call.

Sincerely,

Margaret M. Hofacker

Margaret M. Hofacker
Environmental Engineer

enc: Schedule of Events, Laurel Landfill
Calculations to Determine Lateral Extent of Contaminant Plume, Laurel Landfill
Figure 1, Monitoring Well Locations

cc: Jim Worthington, Public Works Director, City of Laurel
Chuck Rogers, Mayor, City of Laurel
J. D. Shaffer, GRI
GRI file 112035

115 North Broadway
Billings, MT 59101
TEL. (406) 248-6771
FAX (406) 248-6770

Table 5
Schedule of Soils and Ground Water Investigation Events
Laurel Landfill, Laurel, Montana

Event	Estimated Completion Time and Date
Schedule Driller	2 weeks, mid July
Install 2 monitoring wells, develop and sample	½ week, early August
Conduct slug tests in new wells	½ week, early August
Conduct pump test in MW-1, MW-2, MW-3	½ week, mid August
Collect data from infiltrometer R-1	late June-September
Survey well locations	1 day, mid August
Sample MW-1, MW-2, MW-3, MW-4	1 day, early September
Evaluate data	3 weeks, September
Write final report	3 weeks, October
Periodic ground water level monitoring	May 1993- April 1994
Complete Post Closure Plan	4 weeks, early August

Calculations to Determine Lateral Extent of Contaminant Plume
Laurel Landfill

Vertical Movement:

Assumption 1: Waste disposal pits were excavated to 10 feet below the original ground surface when active landfilling was occurring.

Assumption 2: The minimum depth to the water bearing zone is 17 feet below the original ground surface in the vicinity of the waste disposal pits.

Assumption 3: Vertical hydraulic conductivity at the site is approximately 8×10^{-8} cm/sec (3×10^{-9} ft/sec).

Calculations:

$$\text{vertical velocity} = 3\times10^{-9}\ \text{ft/sec}\times\frac{3600\ \text{sec}}{1\ \text{hour}}\times\frac{8260\ \text{hours}}{1\ \text{year}} = 0.089\ \text{ft/yr}$$

and

$$\text{time to reach ground water} = \frac{17\ \text{ft} - 10\ \text{ft}}{0.089\ \text{ft/yr}} = 78\ \text{years}$$

Horizontal Movement:

Assumption 1: Horizontal hydraulic conductivity = 3.3×10^{-5} ft/sec.

Assumption 2: Porosity of shale = 10%.

Assumption 3: MW-4 and MW-2 are completed in the same unconfined aquifer.

Assumption 4: The average hydraulic gradient between MW-4 and MW-2 for water level readings taken in November 1992 and May 1993 is 0.047 ft/ft.

Calculation:

$$\text{horizontal velocity} = \frac{3.3\times10^{-5}\ \text{ft/sec}\times0.047\ \text{ft/ft}}{10}\times\frac{3600\ \text{sec}}{1\ \text{hour}}\times\frac{8260\ \text{hours}}{1\ \text{year}} = 46\ \text{ft/yr}$$

Fact 1: Contamination has been detected in the ground water at MW-2.

Fact 2: On-site information indicates that ground water seepage was detected during trenching activities.

Fact 3: Contamination may have contacted the ground water at approximately the same time that waste was placed in the landfill if it contacted seepage immediately.

Fact 4: Contamination may have been placed upgradient of MW-4 as early as 1965 or as late as approximately 1986 (half way through the life of landfill license #203)

Fact 5: Relative to MW-2, contamination may have been placed as far away as 1150 feet in 1965 or as near as a few feet in approximately 1986.

Assuming purely vertical migration from the waste disposal pits, it is calculated that 78 years will elapse between the time the contamination is placed in the landfill and when it reaches ground water. However, contamination has been discovered in the ground water at the site.

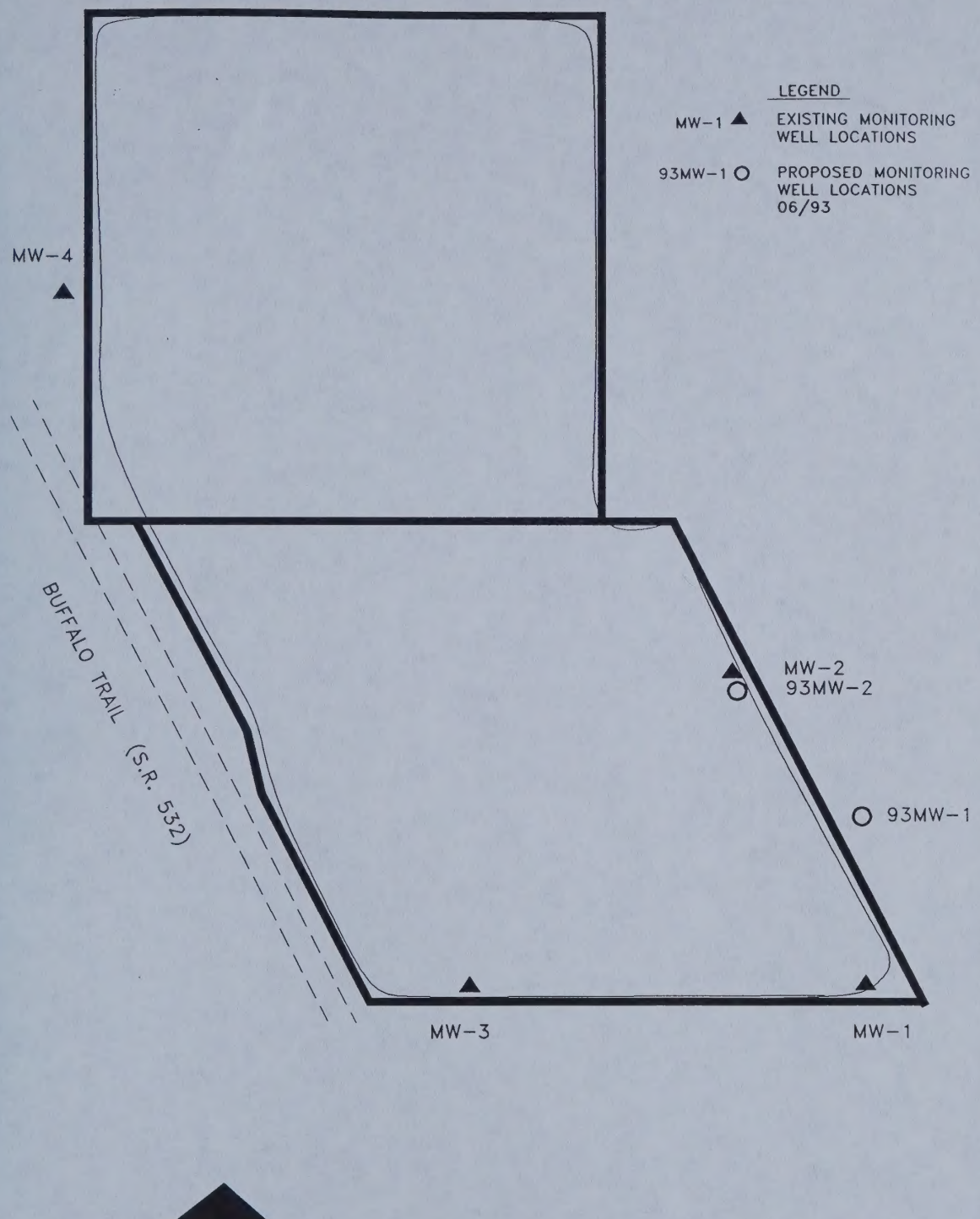
The worst case scenario is that the contamination source was in contact with ground water upon placement in the landfill.

Scenarios:

Scenario 1: Contamination entered the landfill in the first waste load accepted in 1965. Contamination has been moving downgradient for 28 years at a rate of 46 feet per year and is calculated to have migrated 1288 feet from the northwest corner of the initial dump site in the vicinity or approximately 140 feet down gradient of MW-2 by 1993.

Scenario 2: Approximately half way through the active life of the license #203 area (or 1986) contamination entered the landfill when waste filling was occurring in the vicinity of MW-2. The contamination has been moving downgradient for 7 years at a rate of 46 feet per year and is expected to have moved 320 feet downgradient of MW-2.

Recommendation: The downgradient well to be installed in 1993 should be placed approximately 250 feet downgradient of MW-2.



GEO RESEARCH

FIGURE 1

MONITORING WELL LOCATIONS
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

Dear Pat:

Enclosed is a copy of the spring sampling results at the Laurel Landfill which was mailed to you on June 10. We are currently examining the data to develop recommendations necessary to complete the investigations and characterization of this facility. GeoResearch will address your suggestion (per our telephone conversation of June 14) of an additional down gradient well for contaminant monitoring purposes in conjunction with evaluating the current data. We would like to receive your comments as soon as possible so that we can meet with the City of Laurel to discuss the full scope of work and estimated costs for the additional work which will be required at the facility.

As a result of the 30-day laboratory turnaround on these results, we are requesting an extension of the June 29, 1993, deadline for the completion of the final report. According to your comments dated March 29, 1993, the final report should include the results of field work which is yet to be defined based on the spring sampling results. Prior to commencing the required work, GeoResearch must also obtain authorization to proceed and approval from the City of the costs and schedule and subcontract a driller.

To Pat Potts
Solid Waste Program

FAX: 444-1499

2pgs

GeoResearch, Inc.

June 10, 1993

Ms. Pat Potts
Montana Dept. of Health & Environmental Sciences
Solid Waste Program
P. O. Box 200901
Helena, MT 59620-0901

Re: Ground Water Monitoring at Laurel Landfill

Dear Pat:

Enclosed are the laboratory results from the spring monitoring event at the Laurel Landfill. This is the resampling event required by the exceedences detected during the November 1992 sampling event. The presence of dichlorodifluoromethane was confirmed and the presence of trichlorofluoromethane was observed in well 2. Some inorganic parameters also continue to be above background levels.

The key to the sample designations is presented in Table 1 below.

Table 1
Key to Ground Water Samples
Laurel Landfill, May 1993

Sample Designation	Sample Description
MW-1	Monitoring Well 1
MW-2	Monitoring Well 2
MW-3	Monitoring Well 3
MW-4	Monitoring Well 4
MW-5	Duplicate of Well 2
MW-6	Trip Blank
MW-7	Equipment Blank

115 North Broadway
Billings, MT 59101
TEL (406) 248-6771
FAX (406) 248-6770

Table 2 presents the volatile organics that were above detection limits in any one of the samples analyzed.

Table 2
Selected Ground Water Organic Analytes
Laurel Landfill, May 1993

Analyte (µg/l)	Downgradient Wells			Upgradient Well	Trip Blank	Equipment Blank
	MW-1	MW-2[1]	MW-3	MW-4	MW-6	MW-7
Chloroform	<1.0	<1.0	<1.0	<1.0	3.0	2.3
Dichlorodifluoro-methane	<1.0	6.5	<1.0	<1.0	<1.0	<1.0
Methylene chloride	10	2.2	10	10	10	7.5
Trichlorofluoro-methane	<1.0	1.6	<1.0	<1.0	<1.0	<1.0

[1] Average of two analyses

Laboratory results indicate that both the trip blank and the equipment blank were contaminated with chloroform and methylene chloride. Methylene chloride also was observed in the samples collected from the monitoring wells. Deionized water from Energy Laboratories in Billings was containerized in a 5-gallon carboy for use at the site. The QA/QC samples indicate that the levels of methylene chloride observed in the monitoring wells are most likely due to contaminated DI water. Based on these and earlier results, this carboy will be discarded.

It is interesting to note that methylene chloride is a product of the biodegradation of chloroform by an anaerobic species of *Clostridium*. This information is presented on page 151 of the Groundwater Chemical Desk Reference by John H. Montgomery and Linda M. Welkom (Lewis Publishers, 1989).

Concentrations of dichlorodifluoromethane and trichlorofluoromethane in MW-2 and its duplicate (MW-5) are found to be in exceedence of the concentrations found in the background well (MW-4). In November 1992 the VOC analysis of MW-2 indicated 4.3 µg/l dichlorodifluoromethane and less than detectable concentrations (<1.0 µg/l) of trichlorofluoromethane. Both of these compounds are commonly used as refrigerants and aerosol propellants.

Field and corresponding laboratory parameters are presented in Table 3

Table 3
Field and Laboratory Ground Water Parameters
Laurel Landfill, May 1993

Parameter (µg/l)	Downgradient Wells			Upgradient Well
	MW-1	MW-2[1]	MW-3	MW-4
Field pH (standard units)	6.11	6.69	6.75	6.34
Laboratory pH (standard units)	7.0	7.4	7.7	7.4
Field Specific Conductance (µmhos/cm @ 25 C)	27,600	19,700	33,200	8,250
Laboratory Specific Conductance (µmhos/cm @ 25 C)	26,200	18,700	32,700	8,030
Field Temperature [2] (C)	13.5	11.2	14.1	12.1
Field Dissolved Oxygen (mg/l)	0.9	3.9	2.9	7.5

[1] Average of two analyses
[2] Average of two temperatures

The inorganic parameters of concern which were mentioned in the your comments dated March 29, 1993, are presented in Table 4.

Table 4
Inorganic Ground Water Analytes
Laurel Landfill, May 1993

Analyte (µg/l)	Downgradient Wells			Upgradient Well
	MW-1	MW-2[1]	MW-3	MW-4
Chlorides	189	184	304	73
Nitrates as N	<0.05	51.7	<0.05	1.73
Chemical oxygen demand	38	57	<1	10
Chromium	<0.06	<0.06	<0.01	0.01
Iron	<0.03	<0.03	1.02	<0.03
Lead	<0.06	<0.06	0.01	<0.01
Manganese	10.1	<0.06	0.13	0.84
Selenium	<0.005	0.26	<0.005	0.10

[1] Average of two analyses

Table 5 presents static water levels and elevations for both the November 1992 and May 1993 sampling events. Approximate contours of equal water level elevation are presented on Figure 1. Static water levels varied by less than 2.25 feet between November 1992 and May 1993 with the largest variation occurring in MW-3.

Table 5
Static Water Elevations
Laurel Landfill

Parameter (ft)	Date (mm/dd/yr)	Downgradient Wells			Upgradient Well
		MW-1	MW-2[1]	MW-3	MW-4
Measuring point elevation		3533.79	3550.94	3557.49	3607.00
Screen interval level		15 to 20	15 to 20	36 to 41	27 to 32
Static water level	11/13/92	5.31	18.26	24.23	27.71
	05/04/93	6.06	18.21	22.00	28.63
Static water elevation	11/13/92	3528.48	3532.68	3533.26	3579.29
	05/04/93	3527.73	3532.73	3535.49	3578.37

If you have any questions or need additional information at this time, please call either me or Jim Shaffer in our Billings office.

Sincerely,

Margaret M. Hofacker

Margaret M. Hofacker
Environmental Engineer

enc: Figure 1
Laboratory results

cc: Jim Worthington, City of Laurel

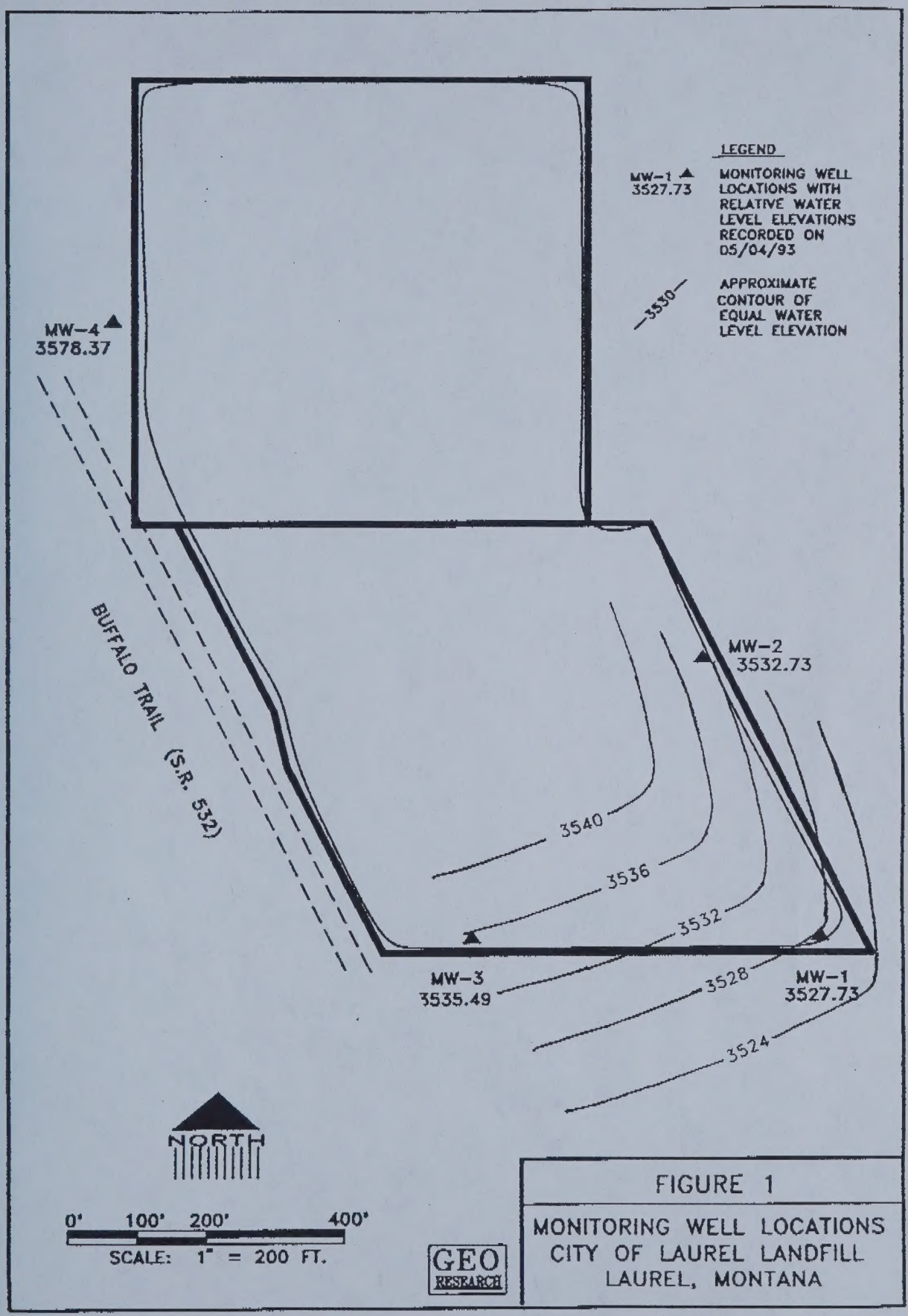


FIGURE 1

MONITORING WELL LOCATIONS
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

GEORESEARCH, INC.

GEO RESEARCH®

December 31, 1992

Mr. Jim Worthington
City of Laurel
P.O. Box 10
Laurel, Montana 59044

RECEIVED
DEC 3 1 1992
MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

Subject: **Hydrogeological and Soils Study**
Laurel Landfill
Laurel, Montana

Dear Jim:

We are pleased to submit our Hydrogeological and Soils Study for the existing landfill for the City of Laurel.

This investigation was performed in response to a request from the State Solid Waste Program dated May 8, 1992 concerning status of the site. The following report provides a description of the investigation performed and our conclusions and recommendations regarding the hydrogeological conditions at the site.

Generally, the ground water at the site is relatively shallow. However, analytical data do not confirm the presence of leachate in the ground water at the site. The poor water quality may be attributable to natural causes or leachate.

We appreciate the opportunity of serving the City of Laurel and trust this report meets your current needs. Four copies of this report were submitted on your behalf directly to the Solid Waste Program in Helena. Comments concerning the content of this report will be provided by the Solid Waste Program at a later date.

Very truly yours,

GeoResearch, Inc.

Curt Coover, P.G.
Project Hydrogeologist

Enclosures
cc: Pat Potts - SWP
Kevin Chappell - DSL

P.O. Box 5597
Helena, MT 59604

TEL. (406) 449-3225
FAX (406) 449-2371

CLOSED
LAUREL LANDFILL
LICENSE NUMBER 203

ENERGY LABS

LABORATORY REPORT, NOVEMBER 1992
SAMPLING

DECEMBER 1992

IS LOCATED IN THE GROUNDWATER
MONITORING REPORTS ARCHIVE,
BOX NUMBER 8

RECEIVED ?

GEORESEARCH, INC.

October 26, 1992

Ms. Pat Potts
Solid Waste Program
DHES
Cogswell Building
Helena, MT 59620

Subject: **Response to Comments Concerning the Work Plan for a Hydrogeological and Soils Investigation at the City of Laurel Landfill**

Dear Pat:

We have received your comments concerning our letter dated October 14, 1992 which responded to your comments on the original Work Plan for a Hydrogeological and Soils Investigation at the City of Laurel Landfill dated September 4, 1992.

Your comments have been noted and GeoResearch agrees to include one field duplicate sample for all parameters to the work plan. Your comments, as well as this letter, become a part of the work plan for the investigation.

Drilling is scheduled to begin tomorrow morning. Drilling equipment decontamination is being conducted today. If possible, I will keep you informed of the drilling progress from the field.

Very truly yours,

GeoResearch, Inc.

Curt Coover

Curt Coover, P.G.
Project Hydrogeologist

cc: Jim Worthington - City of Laurel
Kevin Chappell - Department of State Lands

115 North Broadway
Billings, MT 59101
TEL. (406) 248-6771
FAX (406) 248-6770

File: Yellowstone Co (gndwtr)

GEORESEARCH, INC.

RECEIVED
OCT 1 4 1992
MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
SOLID AND HAZARDOUS WASTE BUREAU

GEO RESEARCH®

October 14, 1992

Ms. Pat Potts
Solid and Hazardous Waste Bureau
DHES
Cogswell Building
Helena, Montana 59620

Subject: **Response to Review of the Work Plan for the Hydrogeological and Soils Study Laurel Landfill**

Dear Pat:

We have received your comments on the work plan for a hydrogeological and soils study a the Laurel landfill in Yellowstone County. This letter presents our responses to these comments. Some of these comments serve to revise the work plan and this letter becomes in integral part of the work plan.

Comment: Specifically, 40 CFR Part 258, Subpart E (i.e. "Subtitle D" groundwater monitoring requirements become effective on October 9, 1993. Therefore, the site would have to be closed by October 9, 1993 (not 1994, as stated in the Workplan text) for the federal requirements for groundwater monitoring to be non-applicable.

Response: 40 CFR §258.50.c.1 states "Existing MSWLF units and lateral expansions less than one mile from a drinking water intake (surface or subsurface) must be in compliance with the ground-water monitoring requirements specified in §§ 258.51-258.55 by October 9, 1996." It should be noted that the Federal Register contained a typographical error and other references indicate that the actual compliance date is 1994. Appendix B of Subtitle D states "The effective date of Part 258 is October 9, 1993, except for two provisions: (1) The ground-water monitoring provisions of §§ 258.51-258.55 which are phased in...".

Comment: The old site (license no. 24) is not required to have a groundwater monitoring plan....

Response: No response necessary.

115 North Broadway
Billings, MT 59101
TEL. (406) 248-6771
FAX (406) 248-6770

Comment: In reference to the landfill areas shown on Figure 2-2 of this Workplan, where was the "old dump site" located which was opened in 1965?

Response: The old dump site was located north and east of the old landfill (License #24). The approximate extent of the old dump will be identified in the report of the hydrogeological and soils study.

Comment: Provide a contour map showing the topography and drainage of this site since cover has been applied [see ARM 16.14.703(1)(a)(ii) & ARM 16.14.703(1)(a)(vi)].

Response: This is being prepared for the closure plan and will also be provided in the report of the hydrogeological and soils study.

Comment: Explain why you think that neither the shallow gravels mapped to the north of the site, nor the Yellowstone Valley gravel unit described as being south of the site will not be present at this site....

Response: The work plan stated "Based on nearby test borings, a gravel unit present in the Yellowstone Valley may be absent at the site (Hutchinson, 1983)." Also stated was "Based on a geologic cross-section (Gosling and Pashley, 1973) the basal gravel thins to the north." Pertinent sections of these references are attached to this letter and are self-explanatory.

Comment: The proposed maximum depth of drilling (150 feet) at the site must take into account the extent of the hydrogeologic units at the site. This would include establishing the thickness of the uppermost aquifer and determining the underlying confining layer in at least one boring [see ARM 16.14.703(1)(a)(iv)].

Response: The depth of drilling at the site will depend entirely upon the geological conditions encountered. The maximum depth was selected based on our experience in the area and may be adequately deep to qualify for an exclusion, depending largely on the hydraulic conductivity of the materials encountered. If an aquifer is encountered at 150 feet, the drilling would proceed to the bottom of the aquifer or a minimum of ten feet from the top of the aquifer. If the geological conditions are not favorable for a no-migration petition and ground water has not been encountered, the drilling may proceed beyond 150 feet to a depth to be determined in the field.

Comment: Please add "R-1" to the legend.

Response: R-1 is a ring permeameter test boring. A revised copy of the figure is attached.

Comment: Additional reasons for not drilling through the refuse.....

Response: No response required.

Comment: Will soil samples be collected for laboratory tests (i.e. grain size distribution, total organic carbon (TOC), soil pH, moisture content and density) be collected from both the unsaturated and saturated zones, except for moisture content which will be measured from unsaturated zone materials?

Response: The soil sampling at the site will depend on the hydrogeological conditions encountered and will be determined in the field by the hydrogeologist. These tests will be conducted on non-bedrock materials. If shallow ground water is encountered as the uppermost aquifer, then some of these tests will be conducted on aquifer materials. If the aquifer is deep, then the tests will be conducted only on unsaturated soil materials.

Comment: Required groundwater sampling parameters are located in **Table 1** of ARM 16.14.706.

Response: No response required.

Comment: It is also important to be cognizant of ARM 16.14.712(2) which states that if closure is not achieved by January 1, 1993, semi-annual sampling events will be required through the 30 year post-closure period.

Response: The closure plan is currently being prepared in anticipation of completing closure by January 1, 1993.

Comment: Do you plan to drill the borings/monitoring wells in the labeled numeric order presented on the map on Figure 2-2?....

Response: This is addressed on pages 5 and 6 of this letter.

Comment: If groundwater is not encountered in the "first two test borings"...

Response: The decision to leave the test borings open for a period of time will depend on the conditions encountered and will be made by the hydrogeologist in the field. Temporary surface casing will be installed by driving the casing and continuously feeding bentonite along the outside of the casing and a locking cap will be installed. The maximum length of time that a boring will be left open will be one day.

Comment: In the event that the first two test borings are dry.....

Response: This statement in the work plan was intended to allow a change in the field activities if the conditions encountered warrant evaluation of the site for a no-migration petition. The change would eliminate the installation of monitoring wells if no ground water were encountered within 150 feet and the materials encountered displayed sufficiently low hydraulic conductivity to qualify for the exclusion within the constraints of §ARM 16.14.714. This would not eliminate the other test borings and unsaturated hydraulic conductivity testing and would most likely result in additional unsaturated hydraulic conductivity testing beyond that specified in the work plan. This maximum depth of drilling may be extended based on conditions encountered in the field and will be determined by the hydrogeologist.

Comment: The Department would like to recommend clustering DMW4 (DMW4A) and DMW3 (DMW3A).....

Response: The shallow water-bearing zone (WBZ) and the uppermost aquifer will be evaluated generally following the suggestions made in the comments: 1) if the uppermost WBZ is discontinuous, then both zones will be evaluated by completing separate wells. Up to three wells may be completed in the shallow WBZ; 2) if the uppermost WBZ is continuous, then a lower aquifer will not be evaluated during this investigation and the four monitoring wells will be completed in this uppermost WBZ. However, if this WBZ is found to be contaminated, a separate work plan may be submitted to evaluate a lower aquifer; 3) if a shallow WBZ cannot be located during this investigation, then all wells will be completed in the uppermost WBZ if one is encountered up to a depth of approximately 150 feet.

Comment: The proposed upgradient monitoring well is off-site. Explain the ownership of the property where this well will be located, the terms under which you will be granted access, and monitoring well installation rights.

Response: The upgradient well will be located on the transfer station site which is owned and operated by the City of Laurel. The exact location of the well will depend on development plans for construction of a permanent transfer station. The downgradient wells are located on School Trust lands under the administration of the Montana Department of State lands and an easement for operation of the landfill was granted to the City of Laurel. No expiration date was specified for the easement.

Comment: Please refer to the enclosed map of the originally undisturbed site topography.....

Response: The Department-selected locations for DMW3 and DMW4 are acceptable to GeoResearch and will be used. However, the location of DMW2 is off the site and access has not been acquired to the adjacent property. Also, we feel that the location of DMW2 is too close to DMW4 for the current level of investigation. Furthermore, it is possible that the direction of ground water movement at the site is to the east and the Department-selected well locations may result in no truly downgradient wells. We propose to eliminate this location and relocate the well to the position of MW-3 on Figure 2-2 of the work plan. This will allow evaluation of more of the site and provide for a well in a potentially downgradient direction. It should be noted that the well locations may be adjusted in the field to allow for access through the fence and other potential obstructions.

The order of well installation recommended by the Department is good for characterizing the hydrogeological conditions at the site and would be preferred by GeoResearch if there was no potential for encountering contamination. However, starting an environmental investigation in the area most likely to be contaminated allows for the possibility of introducing contamination into the later monitoring wells and is clearly divergent from generally accepted practices. Working from "clean" areas into "dirty" areas is a measure of reducing the possibility of cross-contamination separate from and in addition to decontamination of equipment.

We propose to install wells in the following order:

1) upgradient well MW-1
2) hydraulic conductivity test well R-1
3) downgradient well DMW3A or DMW3
4) downgradient well MW-3 (deep or shallow)
5) downgradient well DMW4 or DMW4A

Comment: Decontamination of the drilling equipment is essential.....

Response: The drilling equipment will be decontaminated prior to drilling at the site and between each well installation.

Comment: What screen lengths do you intend to use in each well?...

Response: The screen lengths will be determined in the field based on the thickness of the WBZ encountered. Generally, the screen length will be the full thickness of the WBZ in confined conditions. If unconfined conditions are encountered, the screened interval will straddle the water table encountered at the time of drilling to allow for some seasonal variation of the level of the water table. The maximum screen length will be 10 feet.

Comment: Using the Guelph permeameter to determine hydraulic conductivity in the unsaturated zone...

Response: The Guelph permeameter measures hydraulic conductivity, matric flux potential, and sorptivity in an open boring. Water introduced into the boring can exit the hole through the bottom and sides. The surface area of the sides is much greater than the bottom resulting in a measurement proportionately larger along the sides rather than the bottom. By increasing the head level in the boring, the measurement becomes increasingly dominant in the horizonal direction. Most borehole permeameters function in similar ways and the only method of strictly measuring only the horizontal direction is through the use of packers. Vertical hydraulic conductivity will be measured at the site using the single ring permeameter.

All Guelph measurements will be conducted using a minimum of two head levels. However, if the resulting calculations produce erroneous results due to soil heterogeneities, the single head calculation will be used to provide a somewhat less accurate estimate of hydraulic conductivity. The single head

method has been shown to overestimate field saturated hydraulic conductivity by a factor of 12 which results in an error on the conservative side.

Field-saturated hydraulic conductivity differs from saturated hydraulic conductivity in that a reduction in porosity is present due to entrapped air, but the flow is in the saturated regime. For landfill sites where much of the flow from the base occurs during short term infiltration events, field-saturated hydraulic conductivity is appropriate for modeling. Matric flux potential and sorptivity are used in modeling when wetting-dewetting of the soil is considered. This level of modeling is beyond the scope of the current investigation. If you need additional information, you can browse through our library in our office in Helena.

Comment: The Workplan states that a "field saturated" vertical hydraulic conductivity test (i.e. R-1) will be "conducted" at a depth of 10 feet. Define "field saturated". Explain how this test will be "conducted". Provide the procedure and methodology involved in attaining an accurate "field saturated" vertical hydraulic conductivity.

Response: The single ring method will be conducted according to procedures described in Reynolds and Elrick (1990, Soil Science Society of America Journal, v.54, pp.1233-1241). This method was used at the new Northern Montana Refuse Disposal District landfill near Valier. The apparatus was completed in clay and data were collected for seven months. The data were reduced using the single ring method and the Hvorslev (1951) method. Moisture content and density testing indicated that the soil was saturated or nearly saturated, thus the Hvorslev method was applicable. Hydraulic conductivity values obtained through the two methods of calculations were in close agreement which tends to support the accuracy of the single ring method.

In soft materials, we have found that the ring can be inserted as deep as six to ten inches. In firmer materials, one to three inches has been used. Reynolds and Elrick indicated an accuracy of being within 20 percent for field saturated hydraulic conductivity, but did not address skin factors. Other investigators have indicated an order of magnitude overestimation of field saturated hydraulic conductivity using the single ring method.

Comment: Why aren't groundwater samples collected for volatile organic compound (VOC) analysis preserved with hydrochloric acid?...

Response: The VOC samples will be preserved with two drops of hydrochloric acid per 40 mL vial.

Comment: Please note in the text of this Workplan that GeoResearch's Standard Operating Procedures (SOP) provided in Appendix B of this Workplan is merely a preliminary sampling and analysis plan (SAP).....

Response: A site-specific SAP will be provided with the ground-water monitoring plan.

Comment: A duplicate sample and complete duplicate laboratory analysis of one well...per sampling event is required according to ARM 16.14.706(1)(b)(C)(II)...

Response: §ARM 16.14.706(1)(b)(C) states that the QA/QC plan must include the **frequency** of QA/QC samples including duplicates and blanks. For the first round of sampling, the frequency of field duplicates is zero and the frequency of field equipment blanks will be one per event. The frequency of laboratory duplicates and blanks is one each for selected parameters and surrogate analysis of selected organic parameters which will be determined by the laboratory. The QA/QC requirements for future sampling events will be specified in the SAP included with the ground-water monitoring plan.

Comment: Please be sure to include the following in the Hydrogeological and Soils Study Report: cross-section(s) of the site correlations and hydrogeologic relationships, a potentiometric surface map, descriptions and delineation of the lateral and vertical extent of the gravels (if encountered), and discuss and locate any man-made influences related to the site soils and hydrogeologic effects.

Response: The work plan stated "...the content of this investigation is defined under Title 16, Chapter 14, Subchapter 7, of the Administrative Rules of Montana...". It would be redundant to describe the full contents of the report.

Comment: Decontamination Materials should include methanol, hexane, or acetone for rinsing sampling equipment for organics. Nitric acid which is mentioned, or hydrochloric acid is used for rinsing equipment when sampling for inorganics.

Response: Pesticide grade hexane or acetone will be included in the checklist. However, our experience has shown that the use of an organic desorbing agent has resulted in occasional anomalous analytical results. Therefore, the rinse of organic desorbing agent will be used only if an oily phase is encountered during sampling. The field equipment blank collected at the site will evaluate the adequacy of decontamination procedures. Nitric acid will be added to the checklist.

Comment: Marking water levels on sample containers may be one way to determine if leakage or tampering has occurred....

Response: No response necessary.

Comment: When using field measurement devices/equipment, it is important to document.....

Response: This documentation will be included in the field notebook.

We have begun contacting drillers and anticipate conducting field work at the site as early as the week of October 19. If you have any additional questions or comments, please call me at your earliest convenience.

Very truly yours,

GeoResearch, Inc.

Curt Coover, P.G.
Project Hydrogeologist

cc: Jim Worthington - City of Laurel
Kevin Chappell - Department of State Lands

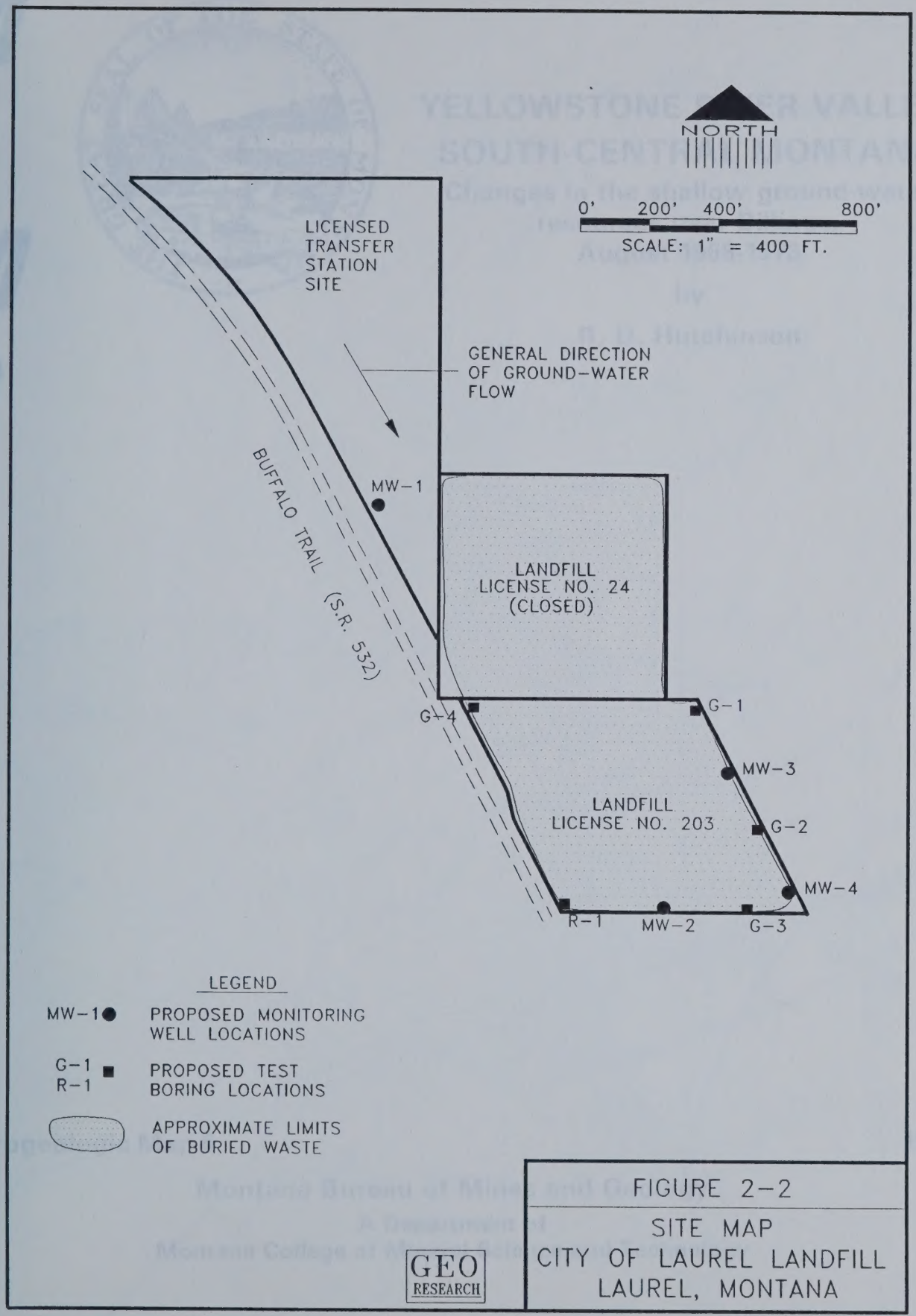


FIGURE 2-2

SITE MAP
CITY OF LAUREL LANDFILL
LAUREL, MONTANA

GEO RESEARCH

$5.00

MBMG

YELLOWSTONE RIVER VALLEY, SOUTH-CENTRAL MONTANA

Changes in the shallow ground-water resources near Billings, August 1968-1978

by

R. D. Hutchinson

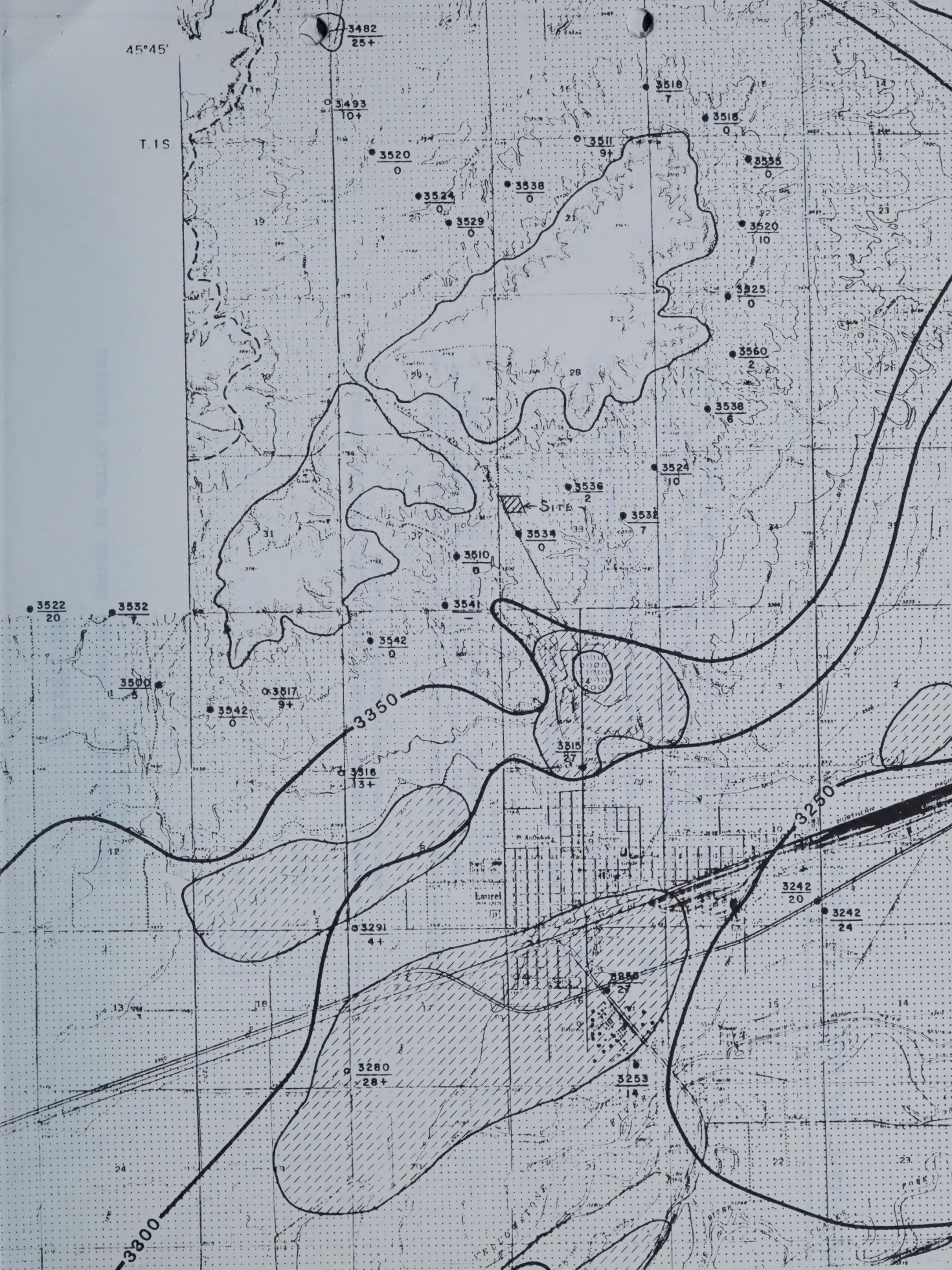
Hydrogeologic Map 6

1983

Montana Bureau of Mines and Geology

A Department of

Montana College of Mineral Science and Technology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3542
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3350
3515
27
3516
13+
3250
3242
20
3242
24
Laurel
3291
4+
3856
27
3280
28+
3253
14
3300

EXPLANATION

TOTAL THICKNESS OF SAND AND GRAVEL IN VALLEY ALLUVIAL DEPOSITS, IN FEET

0-25

25-50

50-75

CONTACT BETWEEN BEDROCK AND VALLEY ALLUVIAL DEPOSITS--Dashed where approximately located

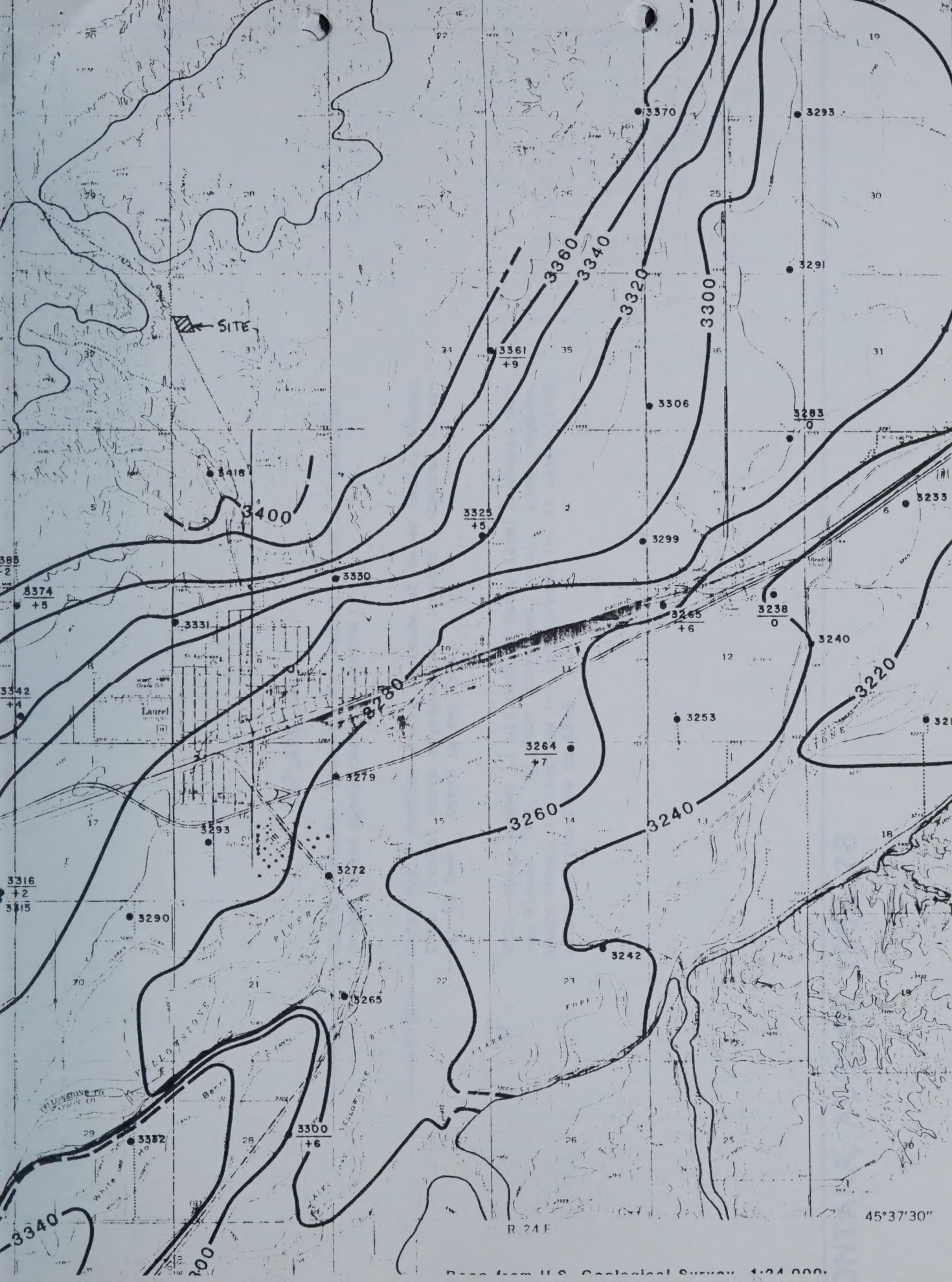
—3200— BEDROCK CONTOUR--Shows altitude of bedrock surface beneath valley alluvial deposits. Dashed where approximately located. Contour interval 50 feet. Datum is sea level

WELL WITH GEOLOGISTS' LOG

$\frac{3178}{16}$ • Upper number is altitude of bedrock surface, in feet above sea level. Lower number is total thickness of sand and gravel penetrated, in feet

$\frac{3116}{6+}$ o Upper number is altitude of bottom of well which did not penetrate bedrock, in feet above sea level. Lower number is total thickness of sand and gravel penetrated, in feet

ONTANA, AUGUST 1968-78



Base from U.S. Geological Survey, 1:24,000;

EXPLANATION

———— --- CONTACT BETWEEN BEDROCK AND VALLEY ALLUVIAL DEPOSITS--Dashed where approximately located

——3180— — WATER-TABLE CONTOUR--Shows altitude of water table, August 1978. Dashed where approximately located. Contour interval 20 feet. Datum is sea level

$\frac{3192}{+2}$ • WELL--Upper number is altitude of water level measured during August 1978, in feet above sea level. Lower number, where shown, is increase (+) or decrease (-) in water-level altitude from 1968 to 1978

NTANA, AUGUST 1968-78

INTRODUCTION

The Yellowstone River flows from Yellowstone National Park in Wyoming to the Missouri River near Williston, North Dakota (see location map). The valley of the Yellowstone River is one of the few water-rich areas of eastern Montana. About 13 percent of the State's population lives along the river in and near Billings. With a population of about 66,000 in 1978, Billings is the State's largest city and one of the fastest growing. The populations of nearby communities of Huntley, Laurel, and Park City also are increasing rapidly.

The ground-water resources of the valley between Billings and Park City were studied during August 1968 by Gosling and Pashley (1973). However, increasing population and concerns for the water supply necessitated that the shallow ground-water resource be re-evaluated. The purpose of the study described herein was: (1) To document any changes that may have occurred in the quantity and quality of shallow ground water since the initial study, (2) to better define the occurrence of water in the unconsolidated-rock deposits of the area, and (3) to expand the initial study area to include Huntley, northeast of Billings.

Wells inventoried during the initial study were revisited in August 1978 and, where possible, water levels were measured and water samples were collected for determination of specific conductance. Additional wells were inventoried to provide a uniform data network throughout the study area. Water samples from 34 wells were selected for comprehensive chemical analysis. All public files of water wells and test holes were reviewed, and selected records were verified by onsite inspection.

GEOLOGY

The Yellowstone River has eroded a wide valley in Cretaceous bedrock units having a total thickness of about 4,000 feet in the study area. Cretaceous rocks are exposed as a prominent sandstone cliff along the north side of the valley and as shale hills along the south side.

Unconsolidated deposits beneath the valley consist mostly of clayey silt, sand, and gravel overlying the bedrock. The deposits are as much as 120 feet thick near the sandstone cliff and generally thin toward the Yellowstone River. At the base of the cliff and the shale hills surrounding the valley, silt and silty clay have accumulated as slopewash and alluvial fans. Three prominent terraces have formed between these deposits and the Yellowstone River. Materials underlying the terraces generally grade from silt to sand and gravel toward the river and become finer grained from west to east in the study area.

Total thickness of sand and gravel deposits (thickness of alluvium minus thickness of silt and clay) is less than 25 feet in most of the area, but may be as much as 75 feet north of Laurel and near the northeast edge of Billings. Well-sorted sand and gravel compose the entire thickness of alluvium in an area as much as 4 miles wide along the Yellowstone River (terraces 1 and 2 of Gosling and Pashley, 1973). Elsewhere, well to poorly sorted sand and gravel beds are buried beneath fine-grained sediments (terrace 3, slopewash, and alluvial-fan deposits of Gosling and Pashley, 1973).

The altitude of the bedrock surface is shown on sheets 1 and 2 by contours and by values calculated from data obtained from drill-hole sites. Total thickness of the alluvium at any point can be estimated by subtracting the altitude of the bedrock surface from the altitude of land surface.

Mapping of the bedrock surface and total thickness of sand and gravel deposits is based on about 850 well logs prepared by drillers and geologists. Drillers' logs provide general information about the materials penetrated and were used as general guides in the mapping. Geologists' logs contain more detailed lithologic information and were used as the basis for interpretation of all the data. The location of wells with geologists' logs is shown on sheets 1 and 2.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MONTANA BUREAU OF MINES AND GEOLOGY

WATER RESOURCES OF THE YELLOWSTONE RIVER VALLEY, BILLINGS TO PARK CITY, MONTANA

By
Arthur W. Gosling and Emil F. Pashley, Jr.

HYDROLOGIC INVESTIGATIONS
ATLAS HA-454

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GOSLING AND PASHLEY—WATER RESOURCES, YELLOWSTONE RIVER VALLEY, MONT. 1:48,000 ATLAS HA-454

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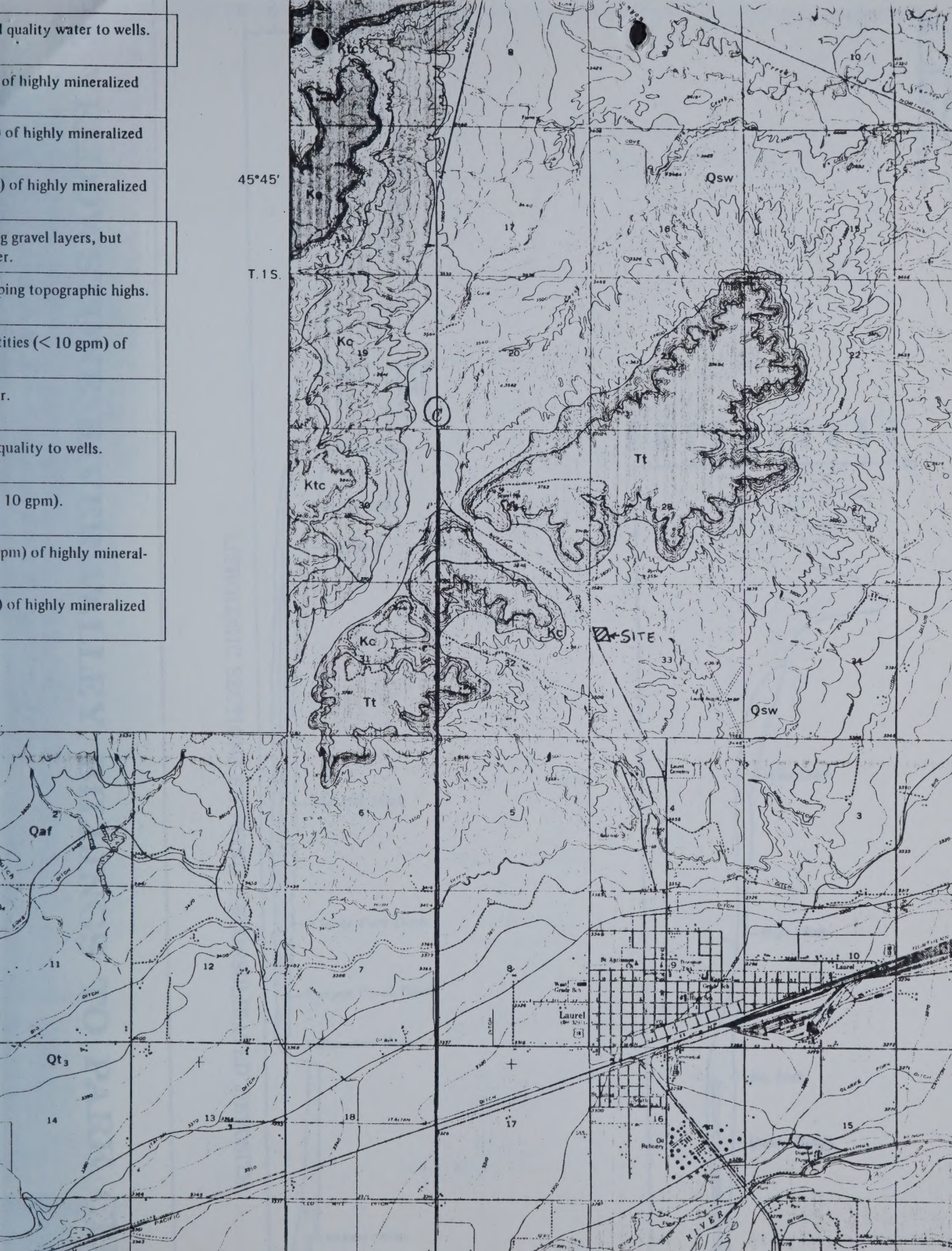

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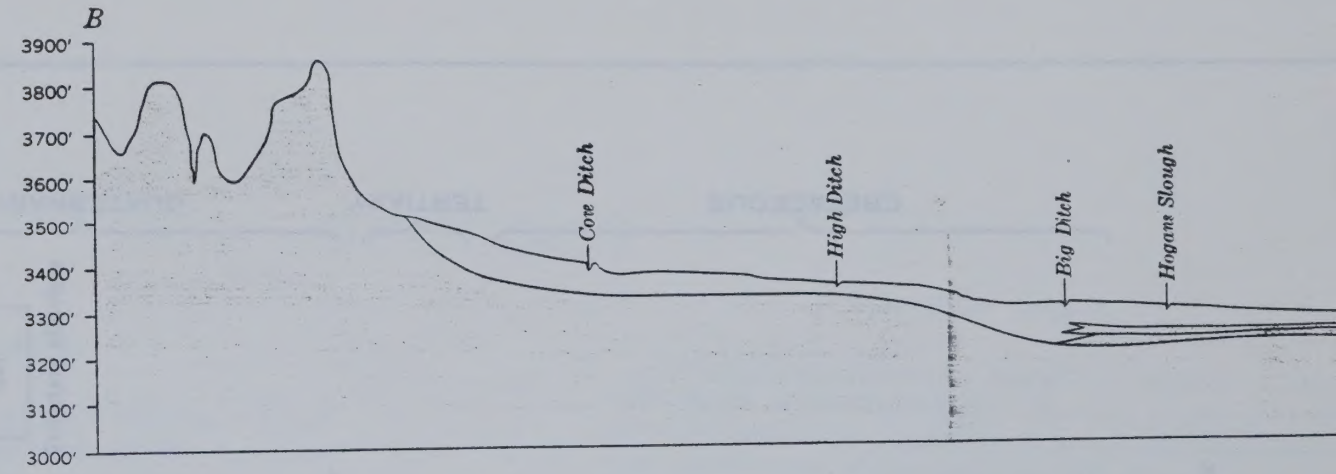

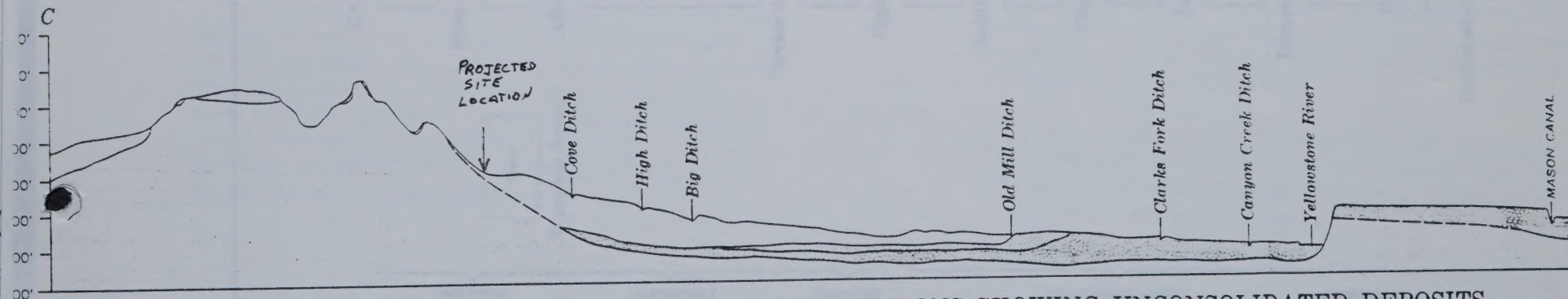

LITHOLOGIC SECTIONS SHOWING UNCONSOLIDATED DEPOSITS

HE YELLOWSTONE RIVER VALLEY, BILLINGS TO PARK CIT

By

Arthur W. Gooling and Emil F. Pashley, Jr.

EXPLANATION

		Qrc	River-channel alluvium	
	Qsw	Qaf	Qal	
	Slopewash deposits	Alluvial-fan deposits	Tributary alluvium	
Holocene		Qt_1		QUATERNARY
Pleistocene		Qt_2		
		Qt_3		
		Terrace deposits on valley floor		
Miocene		Tt		TERTIARY
		High-terrace deposits		
Upper Cretaceous		KJ		CRETACEOUS
		Judith River Formation		
		Kcl		
		Claggett Formation		
		Ke		
		Eagle Sandstone		
		Ktc		
		Telegraph Creek Formation		
Lower Cretaceous		Kc		
		Colorado Shale		

Contact
Dashed where approximately located

GEOLOGY

CRETACEOUS DEPOSITS

Cretaceous sediments with an aggregate thickness of about 4,000 feet are exposed in the region surrounding the study area. Water-bearing and lithologic characteristics of the Cretaceous sediments are summarized in the table. In the upper 3,000 feet of the Cretaceous sediments, sandstone units about 400 feet in aggregate thickness could yield water to wells. Each sandstone unit yields less than 10 gpm (gallons per minute) to wells.

The Yellowstone River valley is bounded on the north by a high cliff capped by the Eagle Sandstone and on the south by low hills underlain by the Colorado Shale (see geologic map). The widening of the valley between Billings and Park City is the topographic expression of the soft Colorado Shale. The valley is less than 1 mile wide west of Park City and at the east edge of Billings where the Yellowstone River cuts through the resistant Eagle Sandstone.

A'

3800'

QUATERNARY DEPOSITS

Unconsolidated Quaternary deposits as much as 120 feet thick overlie the Colorado Shale in the valley as shown on the lithologic sections, which are based on test hole and drillers' logs. At the bases of the sandstone cliff and shale hills, silt and silty clay have accumulated as slopewash. Tributary streams have deposited silt to form alluvial fans at the edge of the terraces. The fine-grained alluvial fan and slopewash deposits thin toward the river.

Three prominent terraces roughly parallel the river in the study area (see geologic map). They are separated from one another by district scarps. The scarp between terrace 1 and terrace 2 is 10 to 20 feet high. The scarp between terrace 2 and terrace 3 is 30 to 50 feet high.

Terrace 1 is adjacent to the river but is not continuous throughout the area. This terrace is 10 to 20 feet above the river surface. Deposits beneath the terrace consist of 20 to 40 feet of coarse gravel and sand.

Terrace 2 parallels the Yellowstone River continuously from Park City to Billings. It is 20 to 40 feet above the river. Deposits beneath the terrace consist of 40 to 60 feet of sandy gravel that contains minor amounts of silt and clay.

Terrace 3 is 50 to 90 feet above river level. The deposits beneath this terrace grade from 20 to 30 feet of well-washed gravel at the southern scarp to about 90 feet of silty clay at the north edge. A basal gravel layer thins to less than 10 feet thick 1 mile north of the scarp and 2 to 5 feet thick 2 miles north of the scarp.

Water-bearing and lithologic characteristics of geologic units

[Partly adapted from Hall and Howard (1929); Knappen and Moulton (1931); Montana Water Resources Board (1969); and Patterson (1966)]

System	Series	Stratigraphic unit	Approximate thickness (feet)	Lithologic characteristics	Water-bearing characteristics
Quaternary	Holocene and Pleistocene	River-channel alluvium	0–20	Well-sorted sand and gravel; contains large cobbles.	Yields more than 50 gpm of good quality water to wells.
		Slopewash deposits	0–120	Silt and silty clay derived by erosion of Cretaceous rocks.	Yields small quantities (< 1 gpm) of highly mineralized water.
		Alluvial-fan deposits	0–100(?)	Silt and silty clay derived by erosion of Cretaceous rocks.	Yields small quantities (1–3 gpm) of highly mineralized water.
		Tributary alluvium	0–30	Silt and silty clay.	Yields small quantities (< 10 gpm) of highly mineralized water.
		Terraces on valley floor	0–60	Gravel and sand layers near the river grading to predominantly silt at north edge of terrace number 3.	Yields 10–60 gpm to wells tapping gravel layers, but silty layers yield very little water.
Tertiary	Miocene to Pleistocene	High-terrace deposits	0–10	Well-sorted sand and gravel.	Usually lies above water table capping topographic highs.
Cretaceous	Upper Cretaceous	Judith River Formation	580	Alternating beds of yellow to brown sandstone and dark-gray shale.	Sandstone layers yield small quantities (< 10 gpm) of water of fair quality to wells.
		Claggett Formation	620	Yellow-gray to light-brown fine-grained sandstone grading to siltstone and gray shale at the base.	May yield highly mineralized water.
		Eagle Sandstone	210	Light-yellow-brown fine-grained sandstone, massive at base and thin-bedded at top.	Yields 5–10 gpm of water of fair quality to wells.
		Telegraph Creek Formation	160	Thin-bedded brown sandstone and shale.	Yields very little water to wells (< 10 gpm).
		Colorado Shale	2,000–2,500	Dark-gray to black shale; contains thin sandy members in the middle and lower sections.	May yield small quantities (< 10 gpm) of highly mineralized water from sandy strata.
	Lower Cretaceous	Cloverly Formation	280	Thick basal sandstone, variegated shale middle member, and sandy shale upper member.	Yields small quantities (< 10 gpm) of highly mineralized water to wells.

13,500 N

13,000 N

LEGEND
- o uppermost Aquifer MW
- Δ Shallow water-bearing zone(s) MW.

MW Re-locations = DMW locations

LAUREL CLASS II LANDFILL

(scale: 1" = 100')
aerial photo 11/15/79
control surveys conducted 5/12/82

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